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Know the Other Man's Job Too

. . . Knute Rockne, of Notre Dame, has an enviable record for producing winning football elevens. As a rule his teams average lighter in weight than their opponents. His success does not come from marshalling an array of "beef eaters," but from developing a capacity for perfect co-ordination.

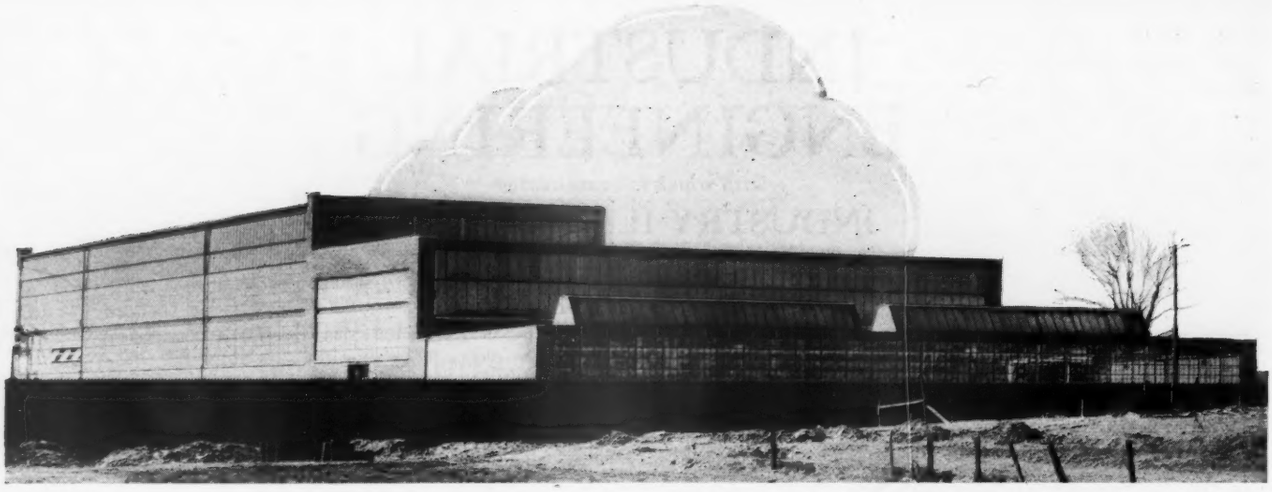
. . . When the quarter back snaps out the signal, each Notre Dame player not only knows exactly what he is to do in the ensuing play, but he also knows what every other player is to do and the relation of his own actions to theirs. As a result there is the perfect support that comes from thoroughly developed co-ordination all along the "line."

. . . Industry is a good deal like a football game. Production is represented by the halfbacks, who carry the ball. The plant engineer, master mechanic, electricians and handling engineers of the "Services to Production," correspond to the "line" which furnishes support and interference. And in the industrial game, co-ordination is just as essential to winning as it is on the gridiron.

. . . Unless the plant engineer and his associates know their fellow worker's responsibilities, and unless they know how their own work affects production progress, there can be no real co-ordination, nor will there be the full measure of success that co-ordination brings.

. . . The development of a plant engineer's "code," as inaugurated by the New England Plant Engineers Club (presented and discussed in this and the preceding issue of INDUSTRIAL ENGINEERING) is a step in the right direction. It helps to define the rules of the game. But the "game" will differ in various industries and in various plants. Each organization must work out its own scheme of co-ordination.

. . . Make it a point this year to learn more about the other fellow's job so that your work may develop into the real teamwork that wins.



This building and its equipment is part of a definite program of expansion

Building for the Future

J. W. MILLSPAUGH
Works Manager

tells how the Chain Belt Company satisfied the need for expansion with modern plant equipment

WITH the growth of our business, particularly the line of fabricated steel products, such as concrete and road machinery, traveling screens, and other bulky articles, our main plant became crowded, which necessitated expansion. Eventually a tract of land was purchased elsewhere and a program of new construction was begun. The plan was to erect new buildings as they were required, but according to a definite scheme or program on the basis that ultimately the entire plant, with additional provision for a reasonable growth, might be moved there and the main plant disposed of.

The last new building erected contains several interesting features, both in the plant arrangement and in the electrical installation. This single-story building is known as our Structural Engineering Shop, Plant No. 4. It houses an engineering, designing and drafting room, a material storage section, and has three parallel bays for fabrication and erection.

The two bays in the illustration on page 55 are for laying out work and shearing, punching, or otherwise fabricating the material which is erected in the bay at the right with the higher ceiling. Material, which consists largely of steel plates and shapes, is handled by 1,500-lb. jib cranes for the light lifting jobs and by traveling cranes, of various ratings for the heavy lifting and carrying.

Jib cranes are provided with electric hoists or chain blocks, according to the work which they are to handle. The 5-ton traveling crane in the storage section and the two 2-ton cranes in the fabricating bays are floor operated; the hoist, trolley and bridge are motor driven, however. These traveling cranes are used only intermittently but are so built that an operator's cage may be added if it becomes necessary. The 15-ton crane in the erecting bay is mounted higher, is used practically all the time and so requires a cage and an operator. All cranes were manufactured by the Harnischfeger Corporation.

The three-phase, 60-cycle power used at this group of new buildings is received at a central substation at 3,800 volts and stepped down to 220 volts for distribution to the various unit buildings. Power for building No. 4 is carried about 550 ft. by means of three No. 4 bare copper wires. These are brought into the corner of the building nearest the substation and terminate in a 1,000-amp., three-pole, inclosed Square D safety switch which will disconnect the entire power service to the building.

From this main switch feeders, consisting of six 500,000-circ. mil and three 750,000-circ. mil cables connected three-in-multiple in 3-in. galvanized conduits, were run through a pipe duct under the floor to the center of distribution which is located at the end of the center bay of the building.

Single-phase service for light is purchased at the wholesale power rate and stepped down from 220 to 110 volts through two 10-kva. and two 15-kva. air-cooled transformers manufactured by Sorgel Electric Company, Milwaukee, Wis.

Obtaining the lighting current from the power service in this way eliminates the installation of a separate lighting circuit from the outside with a separate 110-volt transformer

and meter, which would have resulted in a correspondingly higher kilowatt-hour lighting rate with an additional minimum consumption requirement and a separate lighting bill. In this way the power company is relieved of supplying this extra equipment, and we not only gain the price advantage of lower lighting cost, but do not have the separate bill. There seems to be a natural reaction against paying for electrical energy for power and light at two prices, although the reason for it is easily understood.

The Sorgel air-cooled transformers, which are shown two above and two below the distribution cabinets in the illustration on page 56, are provided with conduit fittings and the connections were made directly to a cabinet containing a fused switch for each of the four transformers. Thus a main switch and fuse are provided for each of the four lighting distribution cabinets which are located conveniently about the plant.

All lighting circuits are wired in polarity with the grounded side to the shell of the socket and identified with a white wire. The lighting distribution cabinets are of the dead-front type with single-pole plug fuses and toggle switches on each circuit. The lighting load of these transformers is phase balanced.

The cabinet at the right in this same illustration contains the fused knife switches to the four power circuits leading to separate distribution cabinets. Two of these distribution cabinets are mounted on this same wall; one is at the extreme left, and the other is in the corner of the room but not shown in this illustration. Connections to and between the various cabinets located at this center of distribution are made through the long junction box or trough which is located just below them. Lines are brought down from this into the floor and distributed to the various outlets by means of rubber-covered wire in conduit.

Still another distribution cabinet, not shown here, contains all of the 220-volt, direct-current circuit switches and fuses for the 10 Harnischfeger cranes

All of the distribution cabinets are of Benjamin Electric Manufacturing Company make, and, in addition to providing fuses, a knife switch is also included in each circuit. The distribution panels are rear-connected and mounted in extra deep cabinets which allow a liberal space in the rear for connecting and for wire runways. The rear sections of these cabinets are made more accessible by removing sections on the sides of the cabinets.

From the four power distribution cabinets individual circuits run to each motor. Each cabinet is provided with spare circuits for future extension. Also, each motor is provided with an inclosed Square D safety switch in addition to the regular starting or contro ling devices. All wiring is totally inclosed in conduits which are rigidly fastened in place with suitable conduit clamps at all motors and at the starting and controlling devices.

We have one deviation from the customary practice, however, in the individual lighting for the machines. The lighting was planned so that, under ordinary conditions, general illumination would be sufficient and individual machine lights unnecessary. It was realized that on dark days and before the general lights were turned on, some machine lighting might be necessary.

Although there are not a large number of machines in the shop, it was decided not to run separate 110-volt lighting circuits to each machine but to connect these lamps in the 220-volt power circuit for that machine. This was done because it was felt that the economy of 110-volt lamps over 220-volt lamps would not justify the extra installation expense and this conclusion has been borne out because they are seldom used. Also, the use of 220-volt lamps would decrease their unauthorized removal when it was found that the lamps

A CORNER OF THE SHOP AND ITS EQUIPMENT

In the illustration above the mezzanine *A* contains the wash, toilet and locker rooms, with the foreman's office directly below. The engineering and drafting room is on the opposite side of the wall *B*; the material stores extend crosswise of the building on this side of the wall. Each bay has its own floor-operated P&H crane, *C* and *D*. A few of the 29 unit heaters *E* are indicated here. The erecting bay at the right has a cage-operated crane. Swinging P&H jib cranes, such as at *F*, serve machines and sections of the erecting floor and so relieve the overhead cranes. A portable acetylene welding unit *G* is used for cutting and welding steel plates and shapes. Push-button (start and stop) at *H* with Square D safety switch and automatic starter, are mounted on the column adjacent to the grinder. The motor is also mounted on the column.

of higher voltage could not be used at home. Lamp loss had amounted to a considerable item.

The lamps which are within reach in the wash and locker rooms are also on a 220-volt circuit. These lamps are seldom used during the day. The loss in light due to the higher voltage is more than overcome through the elimination of removals. Lamps in the office and on overhead units, however, are rated 110 volts.

Another line of electrically driven equipment is the 29 unit heaters which were manufactured by the Modine Manufacturing Company, Racine, Wis. These consist, briefly, of an electric fan which is placed behind a special steam radiator unit about the size and of the general appearance of the radiator on an automobile. The air is heated while being driven through the radiator and the direction of its circulation is controlled by the position of the heater. These unit heaters are driven by $\frac{1}{6}$-hp., 220-volt motors controlled by individual tumbler switches.

Lighting Equipment

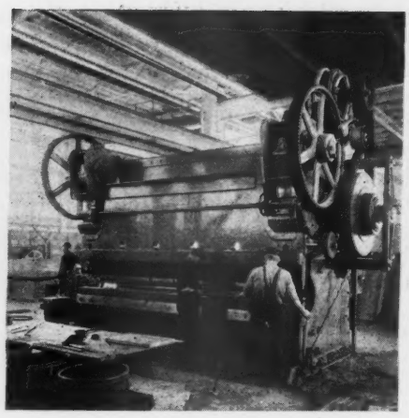
General office, drafting room, blueprint room, waiting room, conference room and shop office—33 fixtures, Graybar lighting units, Catalog 9930-H with tube suspension and 61 individual, adjustable drafting table lights.

Men's wardrobe, men's toilet, women's toilet and passageway—5 fixtures, Graybar lighting units, Catalog 2003 with tube suspension.

Vault—2 drop cords with porcelain, pull-chain sockets.

Paint shop—4 200-watt, R.L.M. dome-type, vapor-proof reflectors complete with conduit stem and canopy alignor.

Machine shop — 52 300-watt, R.L.M. dome-type reflectors complete with conduit stem and canopy alignor.



THE LARGEST MACHINE IN THE ENTIRE SHOP

A 75-hp. motor on this special machine for bending plates is belted to the flywheel which has a built-in clutch. The motor is controlled through a Square D switch and a type CR-1034 compensator with push-button stop.

Steel storage—18 500-watt, R.L.M. deep-bowl-type reflectors complete with conduit stem and canopy alignor.

Erection shop—27 300-watt, R.L.M. deep-bowl-type reflectors complete with conduit stem and canopy alignor.

Steel storage and erection shop—4 200-watt, R.L.M. shallow-bowl-type reflectors complete with conduit gooseneck.

Shop toilet and locker room—9 fixtures, Graybar lighting units, Catalog 2003 with tube suspension.

INCOMING POWER IS RECEIVED IN THESE CABINETS.

A general view showing the location of three of the power cabinets and the main lighting cabinet with the lighting transformers. The motor-generator set, which provides 220-volt direct current for the traveling cranes, is at the right. The apparatus in the corner maintains the vacuum on the Modine unit heaters.

Toolroom—3 60-watt drop cords to hang 2 ft. from floor, complete with cord adjuster, porcelain key-socket and lamp guard.

Night lights—Controlled by three-way and four-way switches, 6 outlets, 200-watt, R.L.M. reflectors.

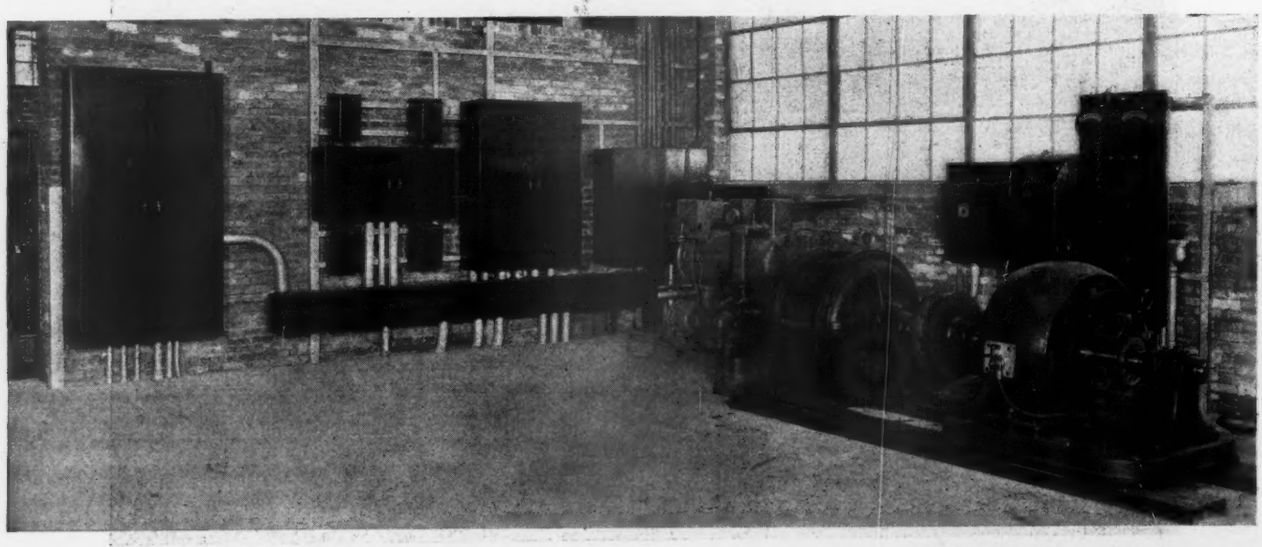
Cranes in erection shop and steel storage—2 200-watt, R.L.M. deep-bowl-type reflectors mounted on each crane and connected to 220-volt, d.c. power service with necessary fuse protection and switch.

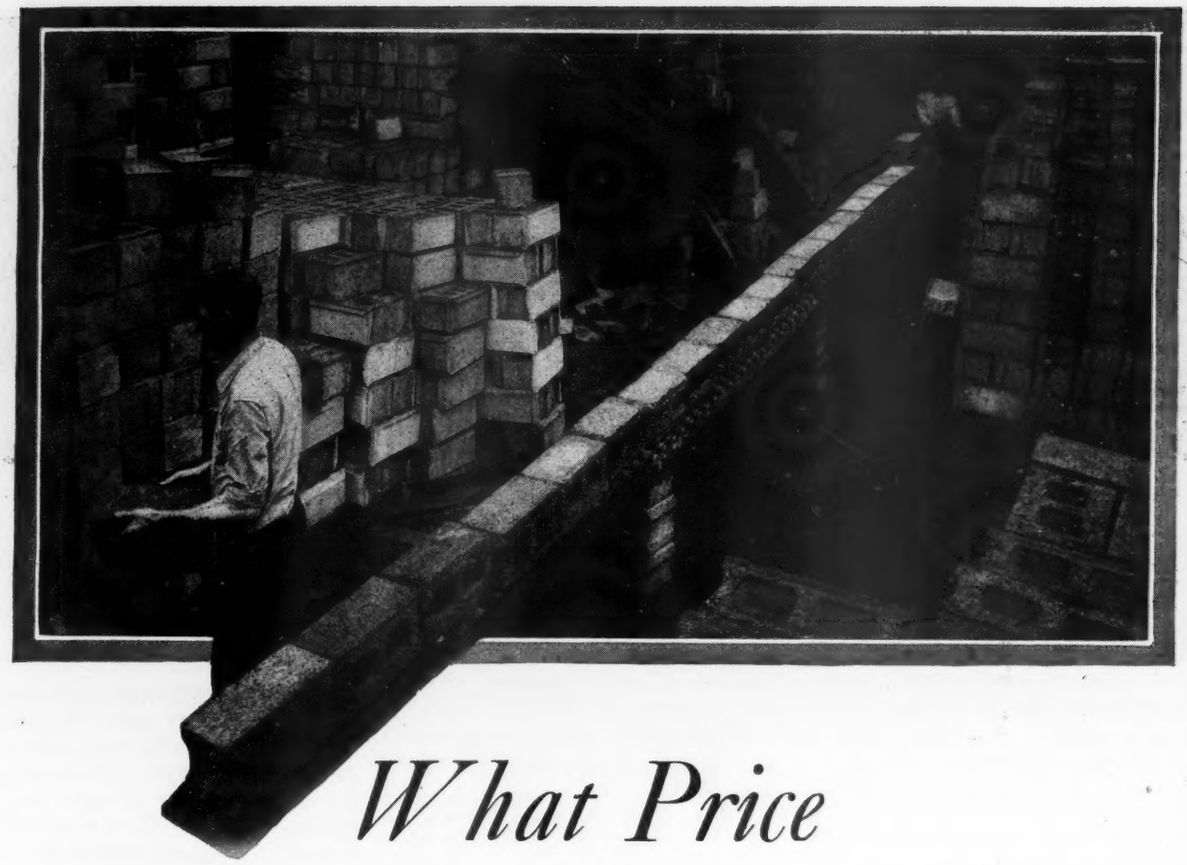
Cranes on fabricating floor—2 200-watt, R.L.M. dome reflectors mounted on each crane and connected to 220-volt, d.c. power service with necessary fuse protection and switch.

Receptacles—Duplex type, for attaching extension cords and connecting small portable tools.

Power Equipment

27 General Electric 220-volt, 60-cycle, three-phase, a.c. motors with total rating of 189 hp. for operating the machinery.
18 220-volt, d.c. motors, on 10 Harnischfeger cranes of various types, total rating of 112¾ hp.
1 50-kw., General Electric, motor-generator set.
29 $\frac{1}{6}$-hp., 220-volt, a.c. motors on unit heaters.
6 60-amp. Arktite receptacles for portable electric rivet heaters.
1 60-amp. photostat, 110 volts, a.c., single phase.
1 90-amp. blueprint machine, 110 volts, a.c., single phase.
60 kw. in lighting load, 110 volts, a.c., single phase.
2 10-kva. Sorgel air-cooled, 220/110-volt, single-phase lighting transformers.
2 15-kva. Sorgel air-cooled, 220/110-volt, single-phase lighting transformers.





What Price
Handling Building Materials?

Mechanical Handling reduces the cost of storage, loading and also labor turnover —says

E. J. TOURNIER

MANUFACTURERS and dealers in building materials must consider two principal problems in connection with handling their products. These problems relate to the storage of finished goods, either during the curing process or for stock, and with loading cars or motor trucks. In addition, there is the significant question of keeping labor on the work.

It can be said of any growing, progressive organization in the building materials field, that one of the early signs of coming success is the installation of mechanical handling equipment. From this follows the corollary, that no such business can produce the volume required for active growth, except by reducing unit production costs. No proof of this statement is required other than a casual inspection of large brick, tile and cement block factories in any locality in which one happens to stop. All of them handle both the raw materials and the finished product mechanically throughout the plant. As more factories install materials handling equipment, thus reducing their costs, the requirement of others with similar apparatus is for additional machinery to make their operations more continuous. Only in this way is it possible to keep ahead of competition.

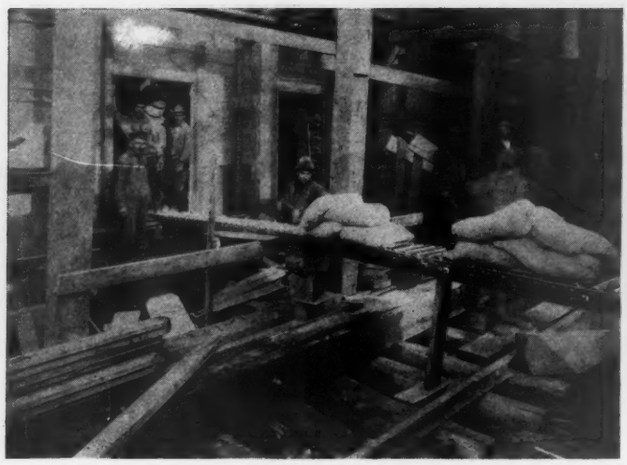
In the larger establishments, however, the difficulty lies in the choice of equipment rather than in deciding whether or not mechanical handling is necessary. When over 80 per cent of the operations consist in materials transfer, the question answers itself.

As an example, a brick manufacturer in eastern Illinois finds that the installation of a gravity roller conveyor for unloading brick saves from one-third to one-half of his former labor cost. This is summarized as follows:

2 teams @ $7.50 per day	$15.00
70 hr. wages @ 27½c. per hr.	$19.25
Total cost for two cars	$34.25
or for three cars	$51.38
Using gravity carrier:	
35 hr. wages @ 27½c. per hour or three cars for	$ 9.63
Saving	$41.75

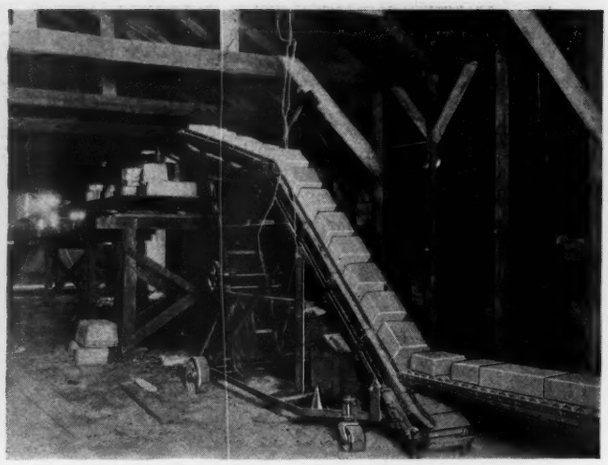
These results, showing as they do 80 per cent savings in labor alone, are not to be considered as exceptional. They are in fact quite ordinary and expected. Ordinarily, the installation of equipment of this type must return the original investment in two years or less.

The application just cited is but one instance where the principal object in view was the reduction of unloading costs. Others, in various



NEW CONSTRUCTION, SOMETIMES CAUSES INTERFERENCE WITH DELIVERY

The gravity roller conveyor here solved such a problem by carrying the cement over obstructions, thereby permitting uninterrupted service. It is said, "This installation paid cash dividends."



RAISING THE GRADE EXTENDS THE LINE

The elevator shown here is used in a gravity line which is limited in length by the elevation of the loading end and the degree of the slope. Push-bar elevators serve to raise material from the low end of one conveyor to the high end of the next one.

parts of the country, could be mentioned where almost similar results were obtained. The superintendent of one plant remarked: "We have handled approximately six million bricks with the Matthews carriers and have found that we could unload our cars for $1.50 per thousand, as against $3.00 to $5.00 per thousand by the old hand method." Another sums up the advantages of the system as, "it is 50 per cent cheaper than wheelbarrows, and we can use boys instead of men in its operation."

Aside from the very important question of the cost of handling materials, there are frequently local conditions where hand labor would be physically impossible. An instance of circumstances of this kind exists in the large cement storage yard of Crowell, Lundorf & Little, Cleveland, Ohio.

In this case, a storage shed for cement in bags was located adjacent to a construction spur track. The track in itself presented an obstacle to handling by means of wheelbarrows or hand trucks, but this would not have been unsurmountable. However, in addition, the crossing was obstructed by miscellaneous construction materials, logs, etc., making the transfer of bags to the trucks beyond the track impossible by the means ordinarily employed under such conditions.

A line of gravity roller conveyor was placed over the track, with the loading end resting on the door-sill of the shed. Vertical planks were used to support the carrier at intermediate points between the loading and discharge points, a distance of about 25 ft. By placing boards face down on the rollers, four bags could be carried on each plank serving as a skid. Although the case under consideration is exceptional and was the solution of an emergency problem due to plant alterations, failure to move the cement out of storage would have meant a daily loss of something over $100.

Other conditions arise in which a gravity conveyor alone will not meet all requirements. As has been pointed out in a previous article, a single unit of conveying equipment is not universally applicable. In many cases it must be used in conjunction with some other type to obtain the best results.

An example of such a condition is to be found in the plant of the Republic Iron & Steel Company, Youngstown Ohio. In that case, fire-bricks were to be transferred from a drying shed to a storage building several hundred feet away. From this point the bricks were transferred by another gravity carrier, to the car door. A gravity roller conveyor seemed admirably suited to the work since the problem was only the transfer of material in a perfectly straight line between two points.

Difficulty arose, however, in the fact that even if the loading end were raised to a point where it could just be reached by the workmen, the other end would touch the ground before the destination could be reached. Obviously, the low end must be raised if the brick can be continued by the aid of gravity.

For this purpose, a short elevator is used, acting much as a "booster" does in an electric transmission line to raise the voltage. The push-bar elevator as used in this case, consists of two strands of roller chains fastened to the ends of flat steel plates forming practically, a continuous apron. One edge of each plate or "pallet" is flanged so that any object resting on the apron will be prevented from sliding downward when operating on an incline. The chains pass over sprockets at either end of the machine. Sprockets with their shafts and bearings are supported on an inclined, structural-steel frame mounted on casters. Below the apron and near the loading end, a small platform carries the electric motor and transmission gears through which the elevator is driven.

The structural steel frame is made in two sections, one of which is in the form of a rigid A-frame, and the other in the form of a hinged boom. At the upper part of the A-frame, a through shaft connects the boom and the rigid section. This shaft also serves as a countershaft to transmit power to the head shaft by means of a simple chain and sprocket connection.

Two inclined struts extend from the end of the boom to a point approximately half way to the ground where they join the A-frame. Racks fastened to the struts engage two spur pinions forming part of a hand-operated winch which serves to adjust the height of discharge of the elevator as may be required by the conditions.

The push-bar elevators of the type described are generally equipped with

REDUCTION OF LOADING COSTS WAS THE OBJECT OF THIS INSTALLATION

Spanning a gap to facilitate the discharge to railroad cars. This view shows the unloading end of a conveyor which receives material from the elevator shown on page 58.

WHERE YARD TRACKS CANNOT BE OBSTRUCTED BY A CONVEYOR

Electric lift-truck with elevating platform being used to transfer hollow tile from storage to cars in the yard of the Los Angeles Clay Products Company

casters to permit their being moved about, and since the gravity conveyors are made in sections, they may also be located wherever required for use. This is a very advantageous feature.

Although no figures are available for the particular installation described, the equipment is capable of handling over 40,000 bricks in an 8-hr. day. On this basis the cost of handling, including labor and fixed charges, is less than $1.00 per thousand.

In some cases it is necessary to make arrangements for the final delivery of materials to cars, different from the installation already described. For example, when the car to be loaded is placed so that a conveyor delivering to it would obstruct a busy yard track, a different layout is required. Cases of this kind illustrate the need of a combination of equipment whose principal use is not primarily cost reduction. In all of them the object is to avoid congestion resulting from blocked paths of travel, to skirt obstructions, or for similar services in which cost reduction is sought as an indirect object.

At the plant of the Los Angeles Clay Products Company, Los Angeles, Cal., hollow tiles are carried in stock in open storage, whence they must be taken for daily shipment. This work is accomplished by means of an elevating platform truck at a cost of less than 75c. per load of 25 tiles.

In giving consideration to proposed installations of materials handling equipment it is quite natural that the probable return on the investment should be given the most careful attention, although in most cases the proposition of manual handling as against mechanical handling permits of but one conclusion. Where plants of the type just described are in question, however, a few figures will show conclusively the economies that will result from the use of the equipment, and a decision in favor of its installation is, therefore, easily arrived at.

The settlement of that question, however, fails to take into account a factor which is of some importance in the determination of handling costs. This factor has to do with labor turn-over. In one instance, it was shown that plant conditions made the simple operation of carrying bags of cement across a track prohibitive for manual labor. This is not to say that it was an utterly impossible job, but that it was attended by very serious difficulties. Conceivably, men could take bags on their backs and carry their burdens over obstructions, with frequent pauses for rest, then slowly starting out again. But, it is unlikely that they would remain long on the job if more desirable work were obtainable elsewhere. Aside from the fact that the frequent hiring of new men is an item of expense, the loss of productive labor when men suddenly quit is infinitely more expensive.

Humane considerations, also, would indicate that heavy loads are better carried by machinery than on the backs of men even though the cost of doing the work were the same in both cases.

PILING BAGS WITH A PORTABLE BAG STACKER

This machine is of the same general type as the push-bar elevator, except that it has a wooden slat apron instead of steel slats.

FIG. 1—A TYPICAL HIGH NARROW BAY WITH TRAVELING CRANE IN AN INDUSTRIAL PLANT

High bays are particularly difficult to illuminate because the light must travel comparatively great distances before it reaches the work; also, a considerable portion of the light usually falls where it is of no use in producing illumination at the floor. The lighting equipment is high overhead and maintenance is difficult. The lighting equipment must also be kept out of the way of the crane. Fig. 2 shows the two methods of mounting the reflector equipment.

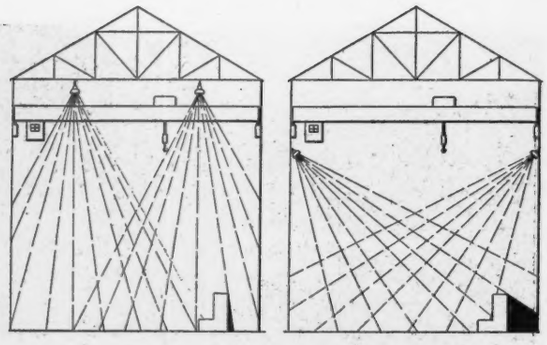


FIG. 2 — REFLECTOR EQUIPMENT MUST BE MOUNTED ABOVE THE CRANE, OR ON THE WALL UNDER THE CRANE RAILS

One disadvantage of mounting reflectors on the side wall under the crane rail is that the light is directed so as to cause excessive glare; also, due to the angular direction of the light, high machinery cuts it off and produces long shadows.

Lighting of I
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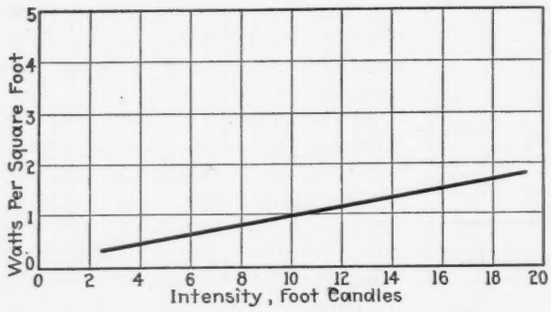


FIG. 3—CHARACTERISTICS OF HIGH-MOUNTING HEIGHT (30 FT.) UNIT

This unit is shown at the right in Fig. 4. When more than one row of reflectors is required, it is good practice to stagger the units so that the crane will obscure only one unit at a time. When the reflectors cannot be reached from the crane, disconnecting hangers should be installed.

LIGHTING of high interiors in industrial plants oftentimes presents troublesome problems whose solution must be carefully worked out, in order to obtain the utmost in illumination on the work at the minimum expenditure for re-

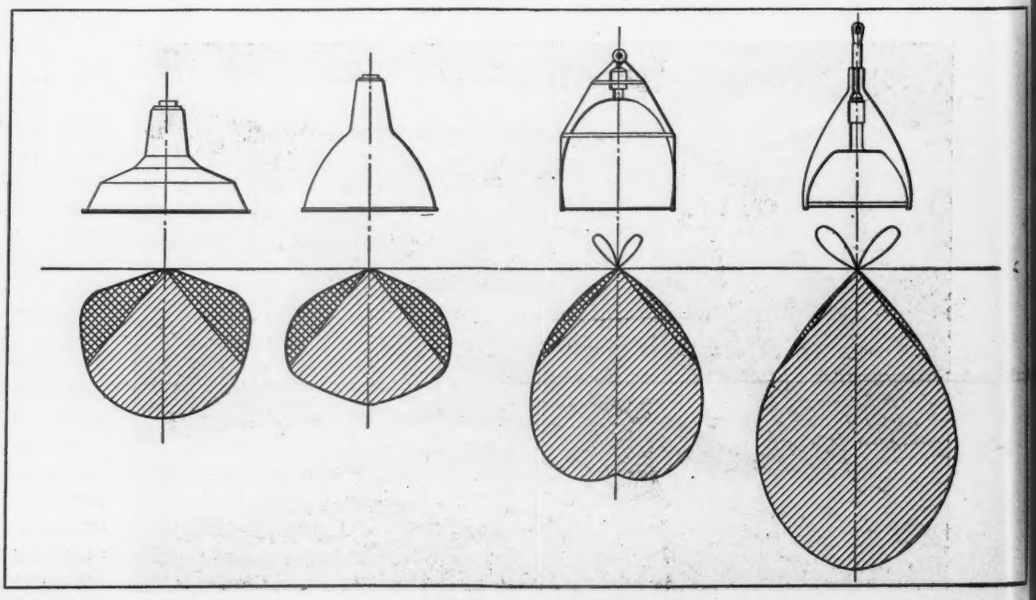


FIG. 4—TYPES OF REFLECTORS USED FOR OVER-CRANE MOUNTING IN HIGH BAYS

The distribution curves are comparable as they are all for the same lamp size (1,000 watts) and are drawn to the same scale. The heavily-shaded area represents the light wasted on the side wall. The lightly-shaded area represents the light that falls directly on the work. The two reflector types to the right have much higher candlepower values in the downward direction than the other types, and are more effective in producing illumination in high bays. The over-all efficiency of the four reflectors shown is approximately equal, but the utilization efficiency, or amount of available light delivered on the work is much greater in the case of the two reflectors shown to the right, as with these the light at high angles, which is for the most part wasted on the upper side walls, is utilized by being redirected to the work.

FIG. 5—HIGH BAY REFLECTOR WITH ASYMMETRICAL DEFLECTOR

When there are balconies where work is done, on either side of the high bay, the reflectors should be equipped with louvres designed to cut off the light from the balcony, but allow it to pass unobstructed in other directions.

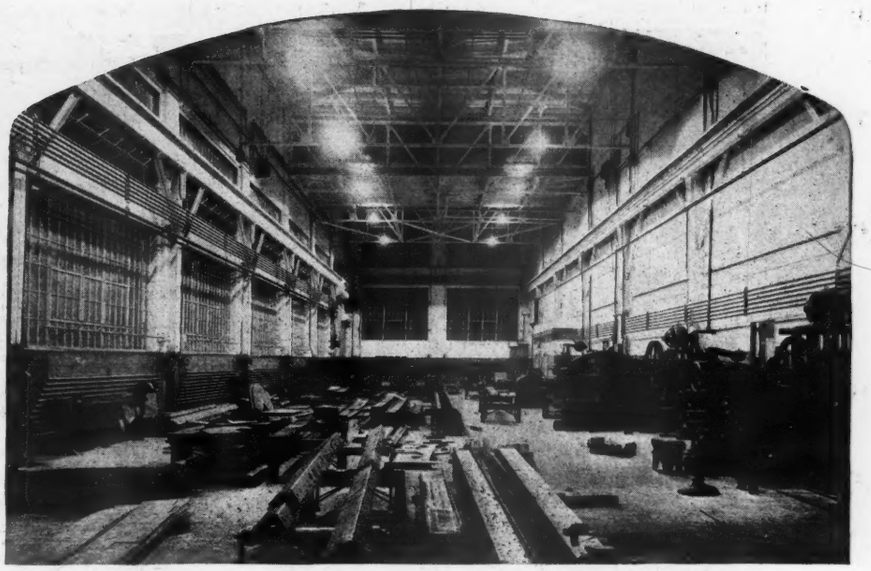


FIG. 6—TYPICAL EXAMPLE OF HIGH-BAY LIGHTING WITH THE HIGH-BAY REFLECTORS

The small amount of upward light gives a daylight effect, instead of the gloomy appearance usual in such interiors.

# of High Bays
al *Plants*

By DAVIS H. TUCK

flectors, current, and maintenance attention. The illustrations on these pages show types of equipment and methods of mounting them that have in practice proved to be successful in providing satisfactory illumination at minimum cost.

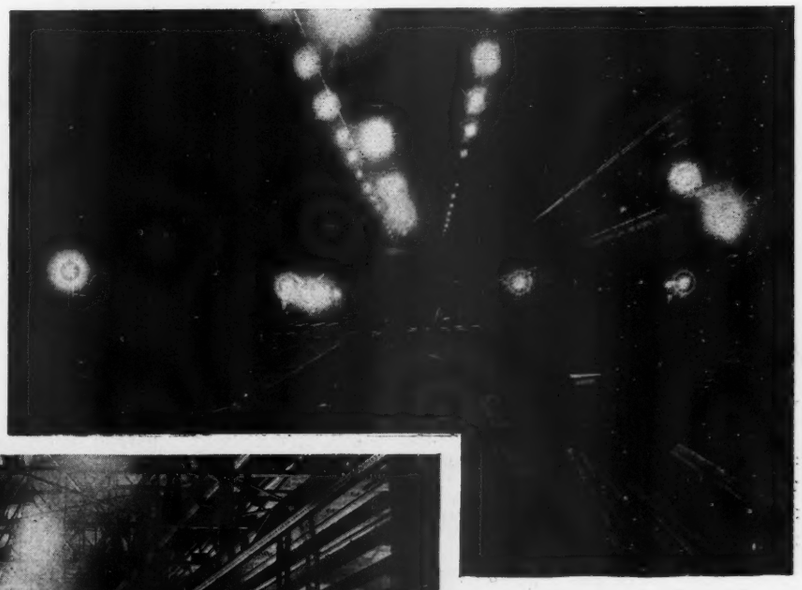
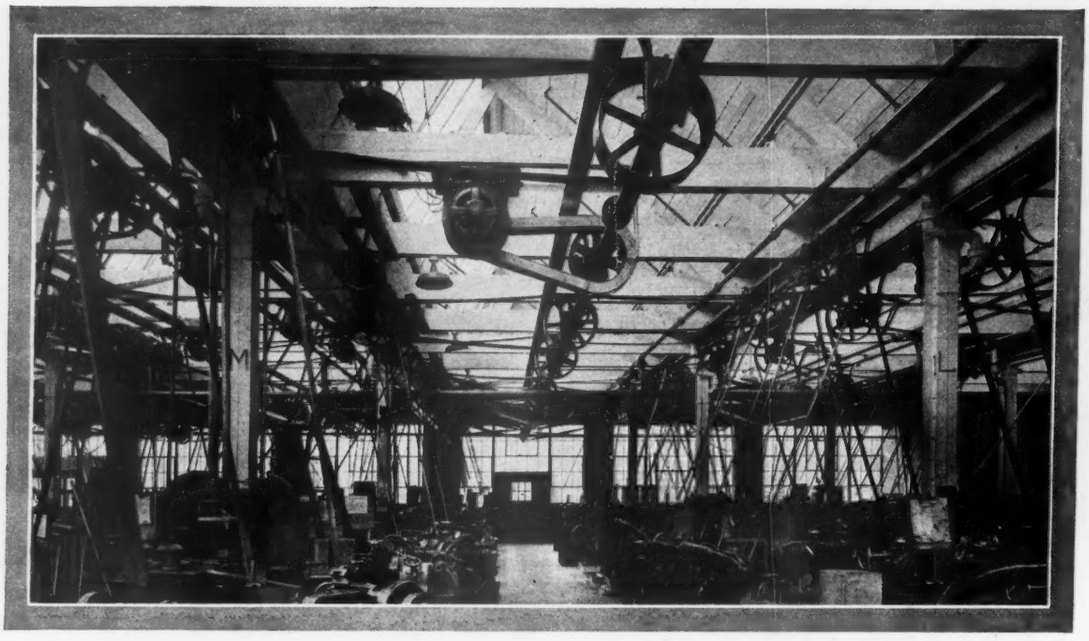


FIG. 7A — EFFECT PRODUCED BY IMPROPER REFLECTORS

In the view above, shallow-bowl and deep-bowl reflectors were used in lighting a high bay in this steel fabricating shop.

FIG. 7B—NOW WE CAN SEE WHAT THE SHOP LOOKS LIKE

This view was taken after high-bay reflectors had replaced the other types. The total wattage is about the same in both cases.



A typical ball bearing lineshaft installation

H. R. REYNOLDS *answers the question*

How Much Power Will Ball Bearings Save *on Lineshafts*

GREAT advances have been made in the past few years by power plant engineers in developing power-generating equipment. Waterwheels, electric motors and steam engines have been developed until they are highly efficient, and are probably developing nearly their maximum possible output.

In line with the savings made in the production of power, there is rapidly developing an appreciation of the savings possible in the use of power. It is in this direction that the greatest economies are still to be effected in most plants.

In this connection, efforts began to be made some years ago to apply some type of ball or roller bearing to lineshafting, in order to take advantage here of the practically frictionless operation of such bearings. In most of these early installations a fairly long roller was employed to support the shaft. Power tests of these applications, although very satisfactory when the shafting was first lined up and level, were very disappointing a few months later when the usual misalignment of parts occurred. This was due to the tendency of the long rolls to wrap themselves around the shaft when conditions were not perfect.

Both ball and roller bearing units for lineshafting have been highly developed since that day, however, and the better types of each now offer positive power savings. This saving in power can be absolutely demonstrated by tests and the amount reduced to horsepower, kilowatts, or dollars and cents. This point is demonstrated in the results of some actual tests that are given later. Before giving the details of these tests, however, some description of testing methods and problems will be of interest.

All of our lineshaft tests are made with an Esterline graphic wattmeter used in conjunction with Westinghouse current transformers. The wattmeter is connected to the motor circuit and a graphic chart obtained of the power input to the motor for each type of bearing.

Before making any tests, shafting should be lined up to make certain of identical conditions for both types of bearings. Shafting should always be checked once a year to make sure that it is properly lined up and the maximum savings thus being obtained.

When conducting tests, readings are usually taken under both full-load and no-load conditions, and frequently with various partial loads. It oftentimes happens that, owing to variations under full load, such as grade of material, irregularity of op-

eration, and so on, the full-load reading is not constant and a fairer figure can be obtained under partial or no load. For example, this was the case in test No. 1 below, where the no-load point gave the best check. This does not mean that the savings at full load are not equal, or even greater, but only that they cannot be accurately checked. Where full-load conditions are constant, no such problem occurs.

It sometimes happens that the test will show almost no apparent power saving with anti-friction bearings, although all of the conditions indicate that the savings are there. It has been found that this is very generally due to the motor having been overloaded when plain bearings were used. When ball bearings were installed, the motor speeded up to normal and the power saving was shown in increased production as a result of speeding up the machines, rather than in kilowatts.

This was the case in test No. 2. It is, therefore, frequently necessary to check production spindle speeds, with both types of bearings in order to get the maximum savings effected by ball bearings. As a matter of fact, in many instances the increased production will probably mean greater returns than the saving in power.

The following tests on lineshafts will throw more light on the above points. The installation tests vary in number of bearings from 10 to 25, and from 53 to 159 per cent in the return on the investment, charges for the bearings including the cost of changeover as well as the price of the bearings. It might be stated here that tests in large plants have become more infrequent during recent years with the increasing conviction on the part of progressive plant engineers that the savings possible with anti-friction bearings are a fact which will be amply demonstrated after installation and that advance proof is no longer required.

It will be noted from the results of these tests that power saving is by no means the only economy and is, in fact, frequently less important than others. Reduction in power, oil, and labor required, and increased production are considered as direct savings whereas other economies such as reduced starting and peak loads, cleanliness, continuous operation and so on, are reckoned as indirect and sometimes incalculable savings.

Ball bearings are frequently installed primarily to eliminate breakdowns of other bearings due to dirt, heavy loads, high speeds, and severe service conditions, with power saving as incidental. Headshafts and heavily-loaded jackshafts are examples of such an application. Saving in maintenance is also one of the most important factors where there are many bearings.

A summary of approximately 90 tests taken in about 25 different industries during the past three or four years on ball bearing hanger boxes shows an annual average return on the investment of 66 per cent in direct savings of power, oil, and labor. This leaves out of consideration entirely the indirect savings, many of which, such as continuous operation, will outweigh even power savings in the profits they can show.

Details of Tests on Ball Bearing Lineshafts

TEST NO. 1—Conducted in mixing room of the Sherwin-Williams Co., Chicago, Ill.

Equipment Under Test—A 25-hp. Wagner, 440-volt, two-phase, 60-cycle, 1,140-r.p.m. induction motor driving a mainshaft at a speed of 237 r.p.m. and a jackshaft. The main shaft was equipped with three $2\frac{3}{16}$-in. babbitted bearings and the jackshaft with two $2\frac{15}{16}$-in. babbitted bearings. The remainder of the shafting delivering power to various tubs was not disturbed during these tests. The connected load was five large mixing tubs, but only three were running during the tests.

Object of Tests—To show the direct saving in power, oil and labor resulting from a change to three $2\frac{3}{16}$-in. and two $2\frac{15}{16}$-in. Fafnir double ball bearing hanger boxes.

Results of Tests:

	Babbitt Bearing Test			Ball Bearing Test			Saving	
Load	Div. on Chart	Meter Constant	Kilowatts	Div. on Chart	Meter Constant	Kilowatts	Kilowatts	Per Cent
No load	0.125	× 25 =	3.125	0.09	× 25 =	2.25	0.875	28
3 tubs running	0.32	× 25 =	8.00	0.27	× 25 =	6.75	1.25	15

Due to the fact that the amount of liquid being mixed in the tubs was variable it is felt that absolutely identical conditions were not obtainable on each test; as a conservative figure the power saving will be taken at the no-load point where conditions were identical. The saving is 0.875 kw.

Saving in Power—A cost of $0.02 per kilowatt-hour and a running time of 55 hr. per week are used.

0.875 kw. × 55 hr. × 50 wks. × $0.02 ..... = $48.13
Yearly saving in power ..... = $48.13

Saving in Oil:

Babbitt bearings — 5 bearings × 50 oilings × 1/40 gal. × $0.40/gal. = $2.50
Ball bearings — 5 bearings × 1 greasing × 1/8 lb. × .15/lb. = .10

Yearly saving in oil ..... = $2.40

Saving in Labor:

Babbitt bearings — 5 bearings × 50 oilings × 1/12 hr. × $0.40/hr. = $8.34
Ball bearings — 5 bearings × 1 greasing × 1/6 hr. × .40/hr. = .34

Yearly saving in labor ..... = $8.00

Summary:

Yearly saving in power	$48.13
Yearly saving in oil	2.40
Yearly saving in labor	8.00
Total saving	$58.53

Annual Return on the Investment:

Saving due to ball bearings	$58.53
Cost of ball bearings	87.14

Annual return on investment = 58.53 ÷ 87.14 = 67 per cent

TEST NO. 2—Conducted in wire-drawing department of the Gilbert and Bennett Mfg. Co., Georgetown, Conn.

Equipment Under Test—A 50-hp. General Electric, 440-volt, three-phase, 60-cycle, 865-r.p.m. induction motor driving a jackshaft and main lineshaft equipped with a total of 14 babbitted bearings: main lineshaft speed 330 r.p.m. Connected load was nine wire-drawing machines, all on at full-load point.

Object of Tests—To determine the actual savings in power, oil and labor resulting from a change to three $2\frac{1}{2}$-in. and eleven $2\frac{5}{16}$-in. Fafnir double ball bearing hanger boxes.

Results of Tests—The graphic charts were compared with the following results:

	Babbitt Bearing Test			Ball Bearing Test			Saving	
Load	Div. on Chart	Meter Constant	Kilowatts	Div. on Chart	Meter Constant	Kilowatts	Kilowatts	Per Cent
No load, belt on loose pulley	0.04 × 100 =	4.00		0.02 × 100 =	2.00	2.00	50.00	
Full load 9 machines	0.57 × 100 =	57.00		52.00 × 100 =	52.00	5.00	8.77	

A full-load lineshaft speed of 330 r.p.m. on the babbitt and 335 r.p.m. on the ball bearings gave 1.53 per cent increase in speed with ball bearings. This is to be

expected as the motor was overloaded, and any decrease in load as that obtained with ball bearings would give an increase in speed.

This is figured as an equivalent 1.53 per cent saving in power, making a total of 10.3 per cent due to ball bearings.

Saving in Power—Kilowatt saving = 57 × 10.3 per cent = 5.87 kw. A running time of 55 hr. per week and a power charge of $0.01 per kilowatt-hour are used in this report.

5.87 kw. × 50 weeks × 55 hr. × $0.01 per kw.-hr. = ... $161.43

Yearly saving in power $161.43

Saving in Oil:

14 Babbitt bearings × 50 oilings × 1/30 gal. × $0.40/gal. = ... $9.34
14 Ball bearings × 1 greasing × 1/8 lb. × $0.15/lb. = ... .27

Yearly saving in oil = ... $9.07

Saving in Labor:

14 Babbitt bearings × 50 oilings × 1/20 hr. × $0.40/hr. = ... $14.00
14 Ball bearings × 1 greasing × 1/12 hr. × .40/hr. = ... .47

Yearly saving in labor = ... $13.53

Summary:

Yearly saving in power $161.43
Yearly saving in oil 9.07
Yearly saving in labor 13.53

Total savings $184.03

Annual Return on the Investment:

Savings due to ball bearings $184.03
Cost of ball bearings 277.38
Annual return on investment = 184.03 ÷ 277.38 = 61 per cent.

TEST NO. 3—Conducted in heading department of the Corbin Screw Corporation, New Britain, Conn.

Equipment Under Test—A 40-hp. Westinghouse induction motor, 550 volts, three phase, 60 cycles, 870 r.p.m., driving the mainshaft at 160 r.p.m. The connected load was nine large headers, twelve small headers and seven medium-sized headers. The bearings were one $2\frac{15}{16}$-in. pillow block, two $2\frac{15}{16}$-in. and eight $2\frac{7}{16}$-in. babbitted bearings.

Object of Tests—To determine the direct savings in power, oil and labor resulting from a change to a $2\frac{15}{16}$-in. Fafnir pillow block, two $2\frac{15}{16}$-in. and eight $2\frac{7}{16}$-in. ball bearing hanger boxes.

Results of Tests:

Plain Bearings				Ball Bearings			
Headers Running			Division	Headers Running			Division
Large	Small	Medium	on Chart	Large	Small	Medium	on Chart
6	8	3	0.44	8	10	6	0.49
6	9	3	0.45	6	10	6	0.45
6	11	3	0.47	6	10	3	0.40
4	11	3	0.42	4	10	3	0.36
7	12	3	0.50	7	10	6	0.47
6	12	3	0.475	7	9	6	0.46
6	12	4	0.49	8	8	6	0.48
7	12	4	0.515	8	8	5	0.46

From these readings a large header requires 0.025, a small header 0.01, and a medium header 0.015 divisions on the chart.

Assume an average load of seven large, ten small, and six medium-sized headers. From the above data it will be found that seven large, ten small and six medium headers will give a reading of 0.525 divisions, with babbitt bearings.

With ball bearings the same combination of headers running gave a reading of 0.47 divisions.

	Plain Bearings			Ball Bearings			Saving	
Load	Div. on Chart	Meter Constant	Kilowatts	Div. on Chart	Meter Constant	Kilowatts	Kilowatts	Per Cent
7-10-6	0.525	× 50 =	26.25	0.47	× 50 =	23.5	2.75	10
No load	0.13	× 50 =	6.5	0.09	× 50 =	4.5	2.0	30

Saving in Power—A cost of $0.016 per kilowatt-hour and a running time of 50 hr. per week are used in this report.

2.75 kw. × 50 hrs. × 50 weeks × $0.016 kw.-hr. ..... = $110.00
early saving in power.

Saving in Oil:

Babbitt bearings — 11 bearings × 50 oilings × 1/20 gal. × $0.40/gal. = $11.00
Ball bearings — 11 bearings × 1 greasing × 1/6 lb. × $0.15/lb. = .28

Yearly saving in oil ..... = $10.72

Saving in Labor:

Babbitt bearings — 11 bearings × 50 oilings × 1/20 hr. × $0.40/hr. = $11.00
Ball bearings — 11 bearings × 1 greasing × 1/10 hr. × $0.40/hr. = .44

Yearly saving in labor ..... = $10.56

Summary:

Yearly saving in power $110.00
Yearly saving in oil 10.72
Yearly saving in labor 10.56

Total saving $131.28

Annual Return on the Investment:

Savings due to ball bearings $131.28
Cost of ball bearings 249.12
Annual return on investment = 131.28 ÷ 249.12 = 53 per cent

TEST NO. 4—Conducted in wire-drawing department of Northwestern Barbed Wire Co., Sterling, Ill.

Equipment Under Test—A 50-hp. Westinghouse, 440-volt, three-phase, 60-cycle, 850-r.p.m. induction motor driving 50 ft. of lineshaft at 358 r.p.m. The lineshaft was equipped with seven $2\frac{15}{16}$-in. babbitted bearings.

Object of Tests—To determine the direct savings in power, oil and labor resulting from a change to seven $2\frac{15}{16}$-in. Fafnir ball bearing hanger boxes.

Results of Tests:

	Babbitt Bearing Test			Ball Bearing Test			Saving	
Load	Div. on Chart	Meter Constant	Kilowatts	Div. on Chart	Meter Constant	Kilowatts	Kilowatts	Per Cent
No load	0.12	× 50 =	6.00	0.075	× 50 =	3.75	2.25	37.5
2-3-4-6 on	0.64	× 50 =	32.00	0.585	× 50 =	29.25	2.75	8.6
All 6 on	0.89	× 50 =	44.50	0.84	× 50 =	42.00	2.50	6.0

Due to variations in hardness and size of wire it is felt that a very conservative figure is obtained at an average of the above three savings. It is felt that the actual saving here is considerably more. However, as we were unable to check the wire going through on both sets of bearings, the only absolute check is at the no-load point. The saving of 2.5 kw. is, therefore, used in this report.

Saving in Power—A cost of $1\frac{1}{3}$c. per kilowatt-hour and a running time of 130 hr. per week are used.

2.5 kw. × 130 hr. × 50 weeks × $1\frac{1}{3}$ c. ..... = $216.67
yearly saving in power.

Saving in Oil:

Babbitt bearings — 7 bearings × 600 oilings × 1/40 gal. × $0.40/gal. = $42.00
Ball bearings — 7 bearings × 1 greasing × 1/4 lb. × $0.15/lb. = .27

Yearly saving in oil ..... = $41.73

Yearly Saving in Labor:

Babbitt bearings — 7 bearings × 600 oilings × 1/30 hr. × $0.45/hr. = $63.00
Ball bearings — 7 bearings × 1 greasing × 1/6 hr. × $0.45/hr. = .53

Yearly saving in labor ..... = $62.47

Summary:

Yearly saving in power $216.67
Yearly saving in oil 41.73
Yearly saving in labor 62.47

Total saving $320.87

Annual Return on the Investment:

Saving due to ball bearings $320.87
Cost of ball bearings 201.60
Annual return on the investment = 320.87 ÷ 201.60 = 159 per cent

TEST NO. 5—Conducted in press room of Fraim, Slaymaker Co., Lancaster, Pa.

Equipment Under Test—The original tests were taken on two motors. First, a 20-hp. General Electric, 220-volt, 60-cycle, two-phase, 1,160-r.p.m. induction motor driving a 155-ft. lineshaft at 250 r.p.m. The lineshaft was equipped with ten $2\frac{3}{16}$-in. and fifteen $1\frac{15}{16}$-in. babbitted, ring-oiling bearings. The connected load was 35 presses. Second, a 15-hp. Fidelity, 220-volt, 60-cycle,

(Please turn to page 92)

Fig. 1—Mold-wound coils are wound on this type of mold

Laying Out and Making Pulled Coils

To meet requirements of shape and the proper nesting of coils during the winding operation

By A. C. Roe

Renewal Parts Engineering Dept. Westinghouse Electric & Manufacturing Company

and

D. H. Braymer

Consulting Editor, Industrial Engineering

THERE are four methods generally used for making armature and stator coils for a.c. and d.c. machines. These are the mold winding, form winding, shuttle winding and pulled shaping.

Mold-Wound Coils.—In these coils the shaping of the wire, either round, square or ribbon, is done on a mold made to the exact shape of the finished coil. In some cases a forming operation is required after the coil is removed from the mold, such as putting in large radius ends, bending leads, etc. The mold is mounted in a manner that permits it to be rotated either by hand or by power, either in a vertical or a horizontal plane, but in all cases the wire is wound off the reel onto the mold and driven to shape by pounding the wire. Mold-wound coils (see Fig. 1) can be wound single and assembled, or wound all in one operation.

The chief disadvantage of the mold-wound coil is that the molds required are expensive to make and a new mold is required for each new coil. Also, the winding time is generally slower.

Molds must be stored, thus taking up space as dead storage. Molds must frequently be repaired while in use and after being in storage for some time may need to be rebuilt, as they are made of hard wood and fiber which warps, splits or swells according to exposure. The investment in molds, therefore, is a considerable item.

Formed Coils.—These coils are made over a stationary former, the coils being shaped by pounding and the use of clamps. The wire in most cases is bare copper strap or ribbon, or double-cotton-covered, asbestos-covered ribbon wire, cut to length and bent into loops or hair pins and then formed.

In formed coils, the leads are generally shaped to fit directly into the proper commutator bars without additional shaping by the armature winder. These coil forms must be made considerably stronger than molds, as more force is required to shape the coils. For heavy strap coils or when a large number of coils are to be made on the one former, it is constructed of iron. This construction is expensive; so whenever possible formers are made of wood, lined with fiber and steel at the working surface and braced with iron.

Formers have the same disadvantages as molds, and in addition are larger and more expensive to make and maintain.

Shuttle-Formed Coils.—Formers for these coils are a special-shaped shuttle required to give the coil its preliminary shape for forming. This type is found mostly in multi-turn ribbon wire coils, where it is necessary to keep the total height of the front end winding as low as possible, that is, the bottom leads, bottom and top coil ends, plus the space between the bottom and top ends and the top leads. The space between coil ends is reduced to a minimum by a special roll in the front diamond point, which requires a special iron shuttle, and with the former and shuttle former types special tools are required to make bends in the leads. Fig. 2 shows a large iron former used on a turbo shuttle former coil; Fig. 3 shows a wood former. A coil in shuttle form is shown at the top, and one coil on the former already shaped.

Thus the cost of the shuttle former is increased over the former by the addition of the shuttle that can be used only for the one coil.

When selecting the type of coil to use and the method of shaping it, all factors such as volume of work, size and kind of conductor, total value of unit, time required to wind coils in the machine, ease of insulating, and need of duplicate coils for replacement or renewal, must be carefully considered.

The advantages of mold, former,

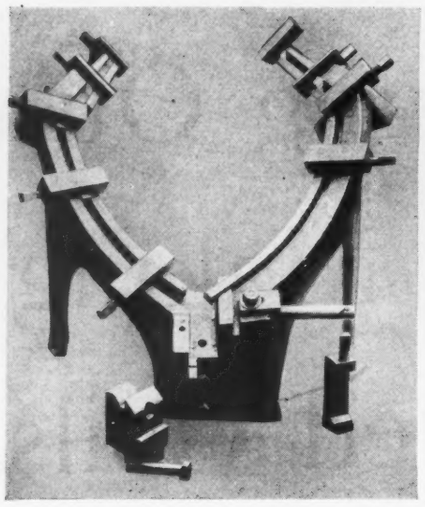


FIG. 2—STATIONARY FORMER USED IN WINDING TURBO COILS OF THE SHUTTLE TYPE

Formers require much space for storage. The coils are shaped by pounding and the use of clamps.

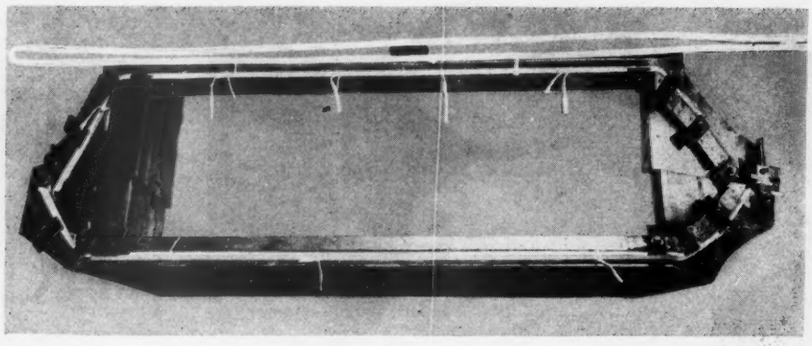


FIG. 3—WOOD FORMER WITH STEEL CLAMPS FOR TURBO COILS WOUND IN SHUTTLE FORM

A coil in shuttle form is shown above, with another coil already shaped placed on top of the former.

and shuttle-former coils are that special, irregular, and accurately-shaped coils can be made. Molds or formers must be used for the shove-through type, concentric chain windings using flat and bent coils, the one-coil-per-slot and the diamond two-layer winding which requires an involute bend at each end of the bottom slot.

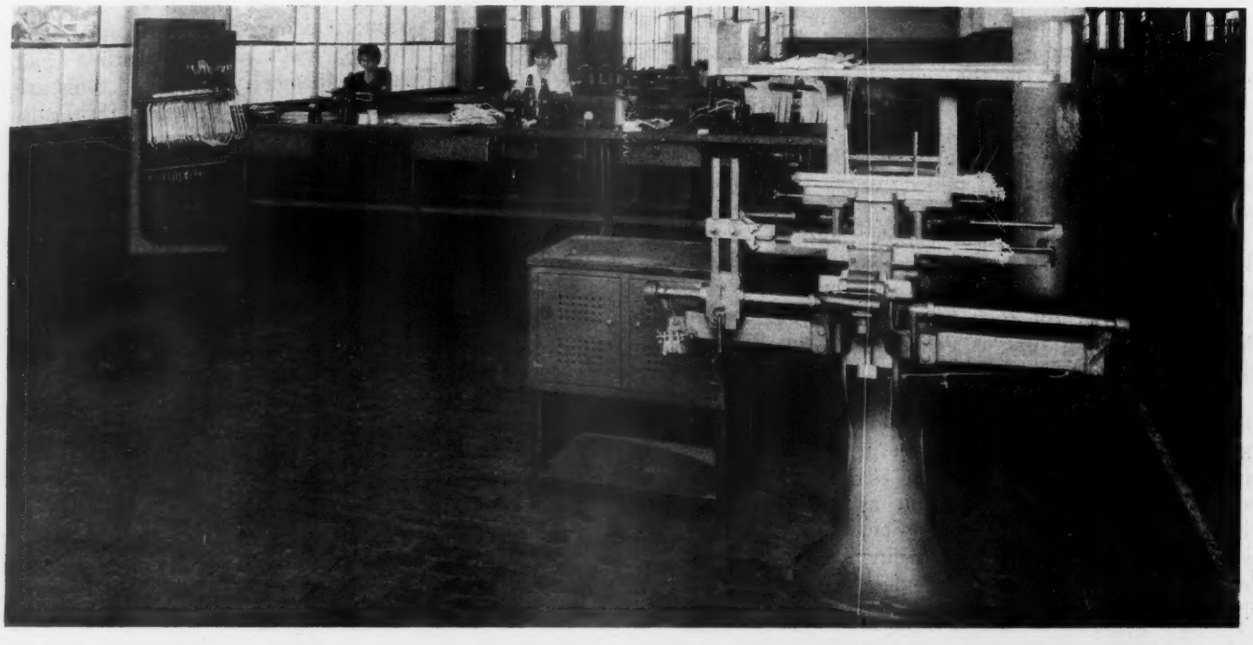
Pulled Coils.—This type of coil is by far the most used and it should be considered in each and every case and rejected only when absolutely unsuited for the application.

The pulled coil is widely used for the following reasons: (1) The shuttles used are simple to make and can be changed quickly and cheaply for use on different coils; thus the space for storage is reduced. (2) Shuttles are not expensive. The average shuttle can be made in two hours and changed to suit another job in one-half to one hour. (3) The machines needed to make shuttles are inexpensive. (4) The pulling machines are easily and quickly adjustable for different coils. (5) It is easy to keep simple records that will make it possible to duplicate coils exactly at some future date. This makes it unnecessary to keep special molds or formers. (6) Shorter production dates can be set and met, due to the time saved in developing and checking molds or formers. (7) Puller coils allow greater flexibility in the selection and use of conductors of shapes and formations impossible on molds or formers. (8) Coils can be wound complete at one operation, thus eliminating soldered joints in some cases. (9) Adjustable shuttles and spreading machines are on the market today that enable any repair shop to make coils without having to make molds or formers, which, if required for one set of coils would run the repair bill up to a figure that would make a new armature or complete machine the cheapest way out of the difficulty.

Figs. 4, 5 and 6 give an idea of the range of coil sizes possible to make on adjustable pulling machines. The three machines shown do not take up any more space than the two formers shown in Figs. 2 and 3.

In the layout and making of pulled coils, there are certain kinks and points that are important to know. In what follows, therefore, details will be given to help the average repair

FIG. 4—TYPICAL SMALL, ADJUSTABLE PULLING OR SPREADING MACHINE SHOWING COIL IN PLACE READY TO BE SHAPED OR PULLED



shop handle pulled coils in the best possible way on ordinary and special jobs.

First, a few general hints that apply to all types of pulled coils will be given, after which we will consider each type separately. The most important feature of any pulled coil is its shape and ability to nest together during winding. The diamond points affect these features in more ways than one. First the height to which the diamond point is held during the pulling affects the final winding. Second, the amount of slope or swivel to the diamond point affects the total amount of copper in the coil and also the coil extension or total over-all length of the coil.

Fig. 7 shows an ideal condition fulfilled by a pulled coil. The top part of the coil is a uniform distance, *A*, below the surface of the core. The top section also has a radius equal to R_1 which is also the radius to which the pulling or spreading machine is set. The bottom of the diamond point is a small distance, *C*, below the bottom of the slots. The distances *A* and *C* are governed by the depth *D* of the coil ends and the diameter of the pin *B* used in the winding shuttle. The diameter of pin *B* is governed in turn by the size and kind of wire used in the coil and the line voltage for which the coil must be insulated.

The dimension R_2 is the radius to which the kick pin jaw, which is the term applied to the fixture that holds the diamond points of the coil while pulling, is set to obtain the clearance *A* in Fig. 7. The distance R_2 is measured from the center line of the pin used on the jaw and the center line of the shaft on the puller.

On some armatures a coil support is used at the rear and front ends of the core. This gives a solid end construction, as the coils lie on an insulated, cylindrical support of iron and the banding wire holds the coil ends down tightly on this support. However these supports present a problem in some cases, as the distance *C* that the coil can drop is limited. Also the distance *A* has a minimum value as an allowance must be made for bands and shove-in clearance. The diameter of *B* is likewise limited. When troubles are run into on these points, the only other remedy is to tilt or slope the diamond point.

Fig. 8 shows the effect of tilting the diamond point of a coil. In Fig. 8*A* the diamond point is vertical or set at 90 deg., and the height of the coil end is $2\frac{1}{2}$ in. Fig. 8B shows the diamond point tilted 10 deg, and the distance *X* has changed from zero to approximately $\frac{1}{16}$ in. Thus tilting the coil end only 10 deg. has reduced the height of the coil ends. Figs. 8, *C*, *D*, and *E* show the further reduction of coil height due to 20, 30 and 45 deg. tilts of the diamond points.

To determine the amount the coil height will be reduced for any angle and coil height, draw an arc with a radius equal to the total height of the diamond point, as line *Y* in Fig. 8*A*. Then with line *F* as a base, the amount that the coil end height will decrease at any given angle can be measured between any point on line or arc *Y* and line *H* and the angle of tilt selected to suit conditions.

The tilting of the coil diamond points also reduces the coil extension and the total amount of copper required to make the coil wind. The tilting of the diamond point gives an involute shape to the coil ends. This effect can be increased by increasing the diameter of the pin *B* in Fig. 7.

The size and kind of wire used in winding the coil also have quite an important bearing on the shape of the diamond point. As a general rule, round wire will adapt itself to any shape while being pulled, but ribbon wire will vary according to its width in proportion to its thickness; that is, if it is wide and thin, trouble will be experienced at the ends of the cells and at the diamond points from the ribbon buckling or bulging. The bulging will also be affected by the

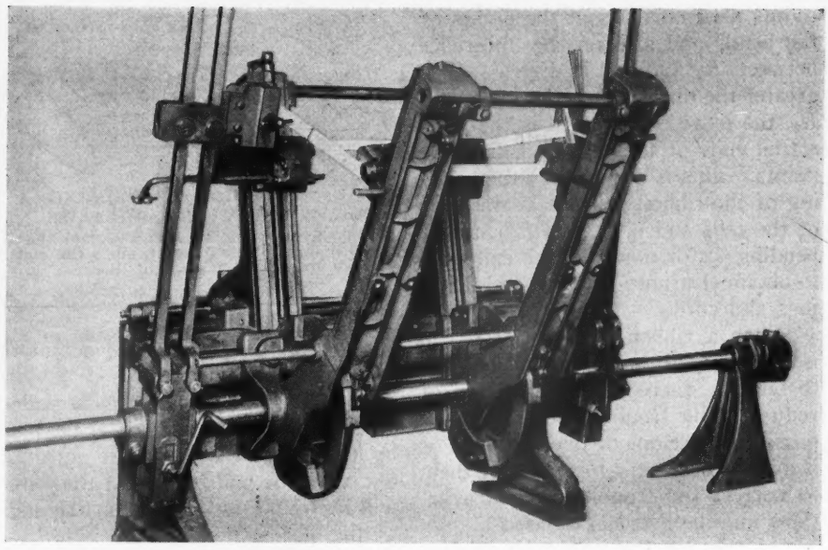


FIG. 5—LARGE SIZE PULLING MACHINE WITH COIL; THIS IS ADJUSTABLE OVER A LARGE RANGE OF COIL SIZES

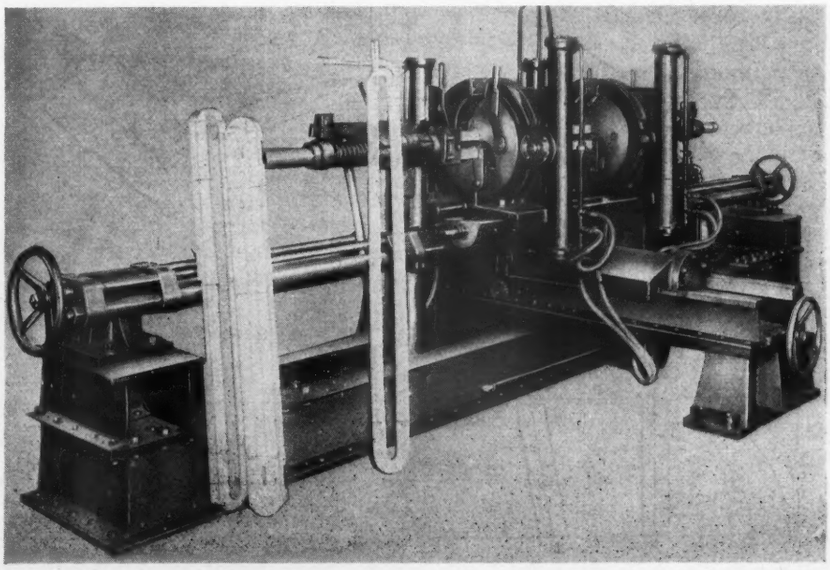


FIG. 6—LARGE AIR-OPERATED ADJUSTABLE PULLING MACHINE
In the foreground is shown the simple shuttle form of coil standing on end against the machine. This gives an idea of the size of this puller. The shuttle coil is 48 in. long.

radius used on irons at the points of the bends and also on the difference between R_1 and R_2, in Fig. 7. The greater the difference between R_1 and R_2, the more complicated is the bend at the ends of the cells and diamond points. This is due to, (1) the bending of the ribbon on edge at the ends of the cells and jaws, and (2), to the bending up or down of the coil ends to obtain clearance between end windings and core.

When a ribbon wire or strap coil is encountered that gives trouble due to bulging, there are a few ways of reducing the trouble and it may be possible to use one or two of these; or it may be necessary to use all of them to correct the trouble. The corrections may be listed as follows:

(1) Change the conductor to two or more in parallel, in place of one wide strap or ribbon. This will reduce the space factor, that is, the ratio of copper to insulation in any given space, and will also make the coil somewhat more difficult to wind and handle, but will stop the bulging.

(2) Change the arrangement of conductors; that is wind on edge and cross over, if the turns per coil are few. This may save time and make a good coil if crossovers are well insulated.

(3) Increase the radius at the ends of the cell irons and at the ends of the kick pin jaws.

(4) Tape the coil before pulling with a layer of 0.007 x 0.75-in. or 1-in. cotton tape, spaced, and dip the coil after taping in a varnish having good plastic and binding characteristics. This will help hold the wires together and make the coil act more as a solid unit.

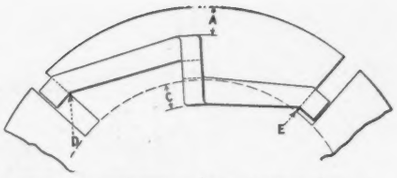


FIG. 9—RESULT OF PULLING A COIL WITHOUT KICK PIN JAWS

This is the same as Fig. 7 except that the distance *A* is greater, since the coil tends to pull on a straight line.

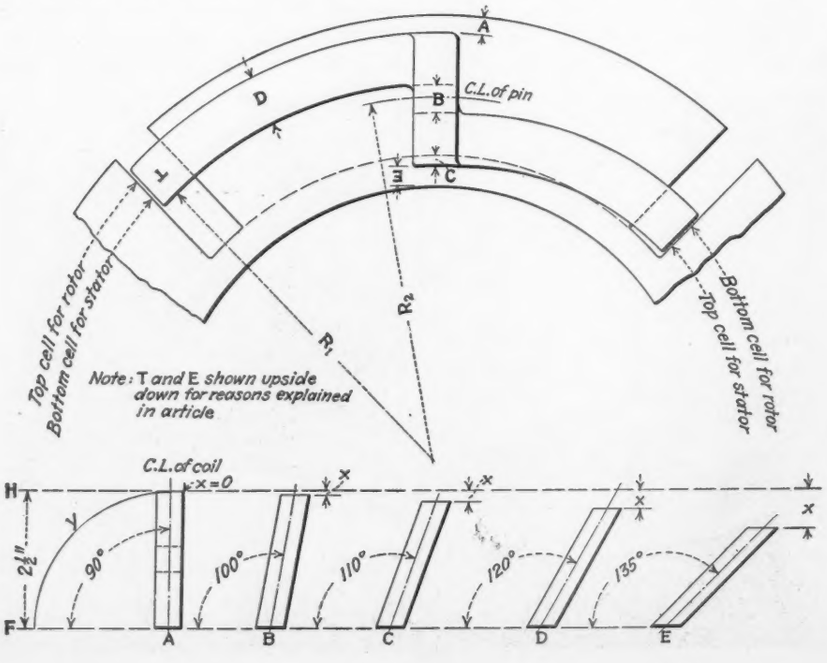
The diamond points of coils pulled on a small radius should be held up by kick pin jaws. If this is not done the coil ends will bulge and the wires will be found out of place at the ends of the slot section.

Fig. 9 gives an idea of the effect of pulling a coil without kick pin jaws. This layout is the same as in Fig. 7 except that the distance *A* is greater, due to the fact that the coils tend to pull on a straight line. This also increases the distance *C*, which means that if a coil support is used the coil will rock on the diamond point and there will be a tendency to force the bottom part of the coil up when the top cell is being driven into the slot. It will be observed that more trouble is experienced in winding an armature with coils that are pulled without kick pin jaws.

Another bad feature shown in Fig. 9, is the sharp bend at points *D* and *E*. This is due to the fixtures on the pulling machine that hold the slot sections of the coil being fixed and having the correct bevel. The result of this sharp bend is to flare out the coil sides at the points where they leave the cell irons; that is, the ends of the straight parts of the top and bottom slot sections.

FIGS. 7 AND 8—THE UPPER DIAGRAM (FIG. 7) SHOWS THE IDEAL CONDITIONS FOR A PULLED COIL

The top part of the coil is a uniform distance *A* below the surface of the core. The top section also has a radius equal to R_1 which is also the radius the pulling machine is set to. The bottom of the diamond point is a small distance *C* below the bottom of the slots. The distances *A* and *C* are governed by the depth *D* of the coil ends and the diameter of the pin *B* used in the winding shuttle. The dimension R_2 is the radius to which the kick pin jaw is set to get the clearance *A*. The lower diagram, (Fig. 8) shows the effect of tilting the diamond point of a coil.



Corrosion of Lead Sheathed Cables

IN A certain instance serious corrosion occurred on some lead-sheathed cables laid in wood troughing filled with a petroleum pitch. This pitch was low in price, but as it was reported by the works chemist to be chemically inert and to contain nothing corrosive there was no hesitation in using it. After about a year there was a breakdown on the cable, which was eventually found to be close to a junction box. When the pitch was removed to expose the cable, the lead sheathing was found to be badly corroded in places. Upon examination of the surface the pitch was found to be unchanged; so a sample was sent to the chemist who again reported it to be non-corrosive.

Two similar cases of corrosion occurred in other installations in which this pitch was used, but the cause could not be determined until the surface of the pitch was examined under a powerful microscope. This test revealed a number of very fine cracks which was invisible to the naked eye. These cracks had evidently admitted moisture to the pitch which had set up a corrosive action on the lead sheath.

If the lead sheathing carries a leakage current the latter will, provided the resistance of soil is high, keep to the lead; if, however, the resistance of the soil is at any time less than that of the lead sheath, the current or part of it will leave the lead and pass to the soil, going back to the lead if the resistance of the soil again increases. Where current passes to and from the lead a certain amount of electrolytic action takes place.

W. E. WARNER.

Shefford, Bedfordshire, England.

Principles Governing the Jurisdiction and Conduct of an Industrial Plant Engineering Department

Charting the responsibility of the

Plant Engineer

Recommended by
PLANT ENGINEERS' CLUB
715 Tremont Temple
Boston, Mass.

A NEW idea in plant management was presented in the January issue of INDUSTRIAL ENGINEERING. It described in detail the plant engineer's code in so far as it refers to interdepartment relationship and contact with management. It set forth conclusively, the code of ethics between department heads and laid down the object, the method of operation and the contact with associates in a manner which could be applied to any industry whether large or small. The editorial work which accompanied this code brought out its history in detail, its inception, development and completion. It emphasized the necessity of ironing out difficulties which now have developed in many plants where there is an overlapping of authority and internal friction. This code will define responsibilities and point out a line of demarkation which simplifies this responsible profession.

There is no plant too large nor one too small for the principles laid down where this routine cannot be employed. Managements who have not organized this all-important phase of their business should put a bit of thought into its completion. It will pay good dividends as a highly organized plant engineering department can be capitalized as a decided asset.

This month's edition describes in detail how it works. It is just like reading a book on the theory of a design, but the blueprint, drawings, and specifications tell us how the machine is constructed, and operated.

The function chart accompanying this discussion, details at a glance the broad responsibilities of the plant engineer. This function chart has been designed with the same breadth of mind so that it can be applied to any industry. Each industry, however, must work out its own application because no two companies operate on the same basis. The fundamentals are here, however, and if applied to your specific problem, amazing results will be obtained.

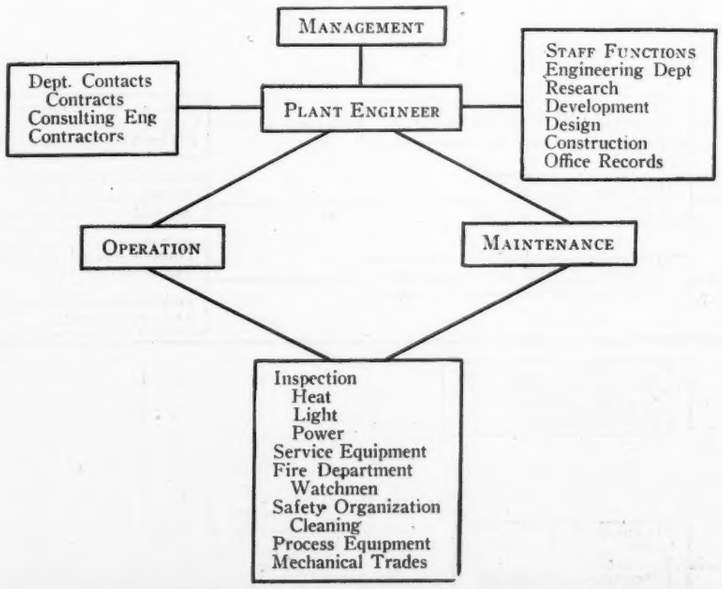
The plant engineer's responsibility is divided into five major functions according to the function chart: research, development and design, construction, operation and maintenance.

You can realize by studying this function chart that the plant engineer not only has to have experience of a consultant who might specialize on any particular line but he must also have the breadth of development in all phases of industrial engineering. He must also have an intimate contact with the specific products manufactured by the plant in question. He should understand all manufacturing problems and their development in his particular plant, so that he may apply his engineering knowledge to the best advantage for the manufacturer of that specific product.

Then again, no organization is complete without some definite principle of management and it is for this reason that the plant engineer's code is set forth in charts I and II, showing the organization required to maintain this intricate system.

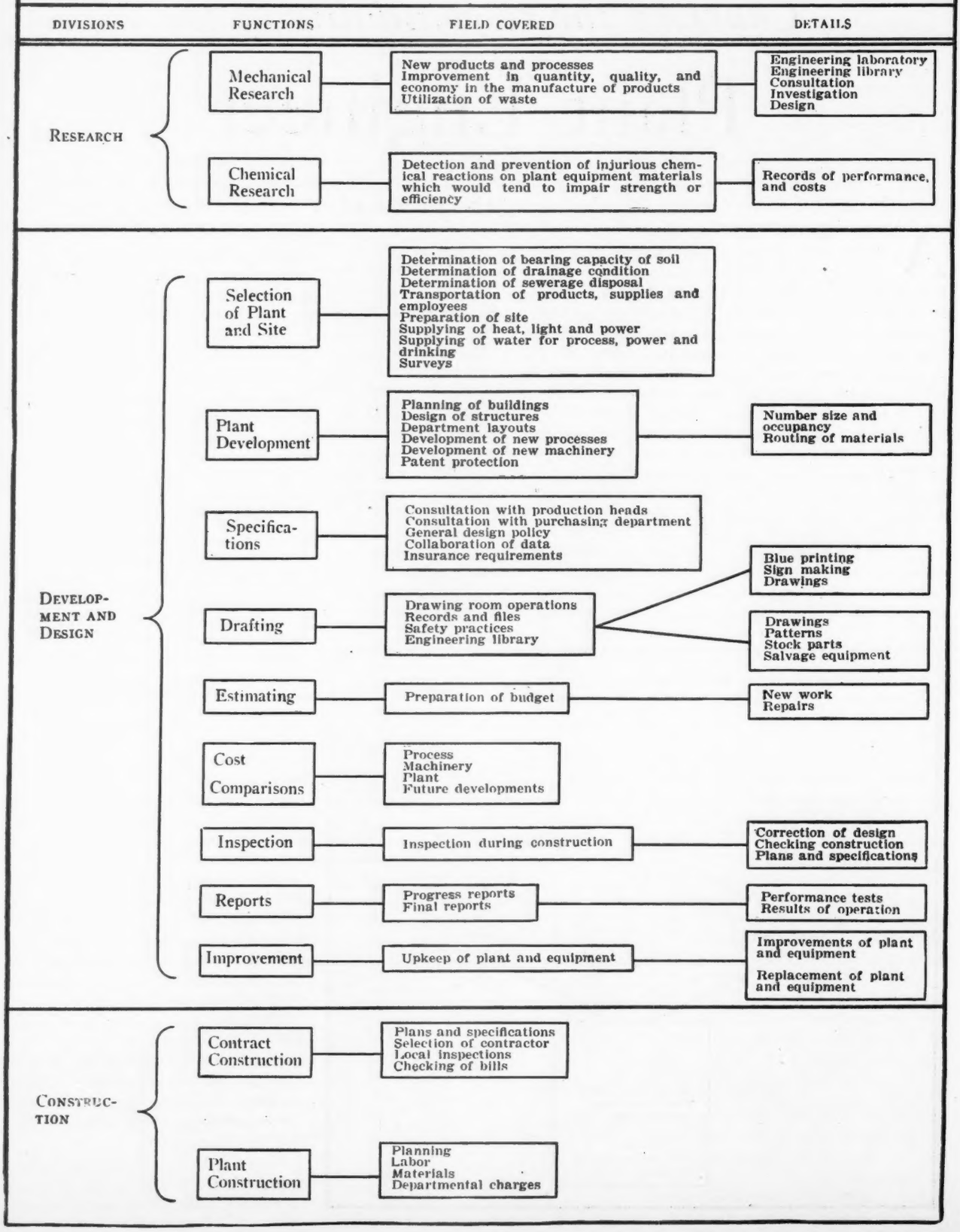
Chart I depicts clearly the organization of a unit plant; that is to say, where the plant, office and production

Chart I—The Relation of Principal Plant Engineering Departments
(One Central Plant)



Part I Function Chart of Plant Engineers Department

Recommended by Plant Engineers Club, Tremont Temple, Boston, Mass., 1928
(Designed by Plant Engineers Club of Boston, Mass., 1927)



Part II Function Chart of Plant Engineers Department

Recommended by Plant Engineers Club, Tremont Temple, Boston, Mass., 1928
(Designed by Plant Engineers Club of Boston, Mass., 1927)
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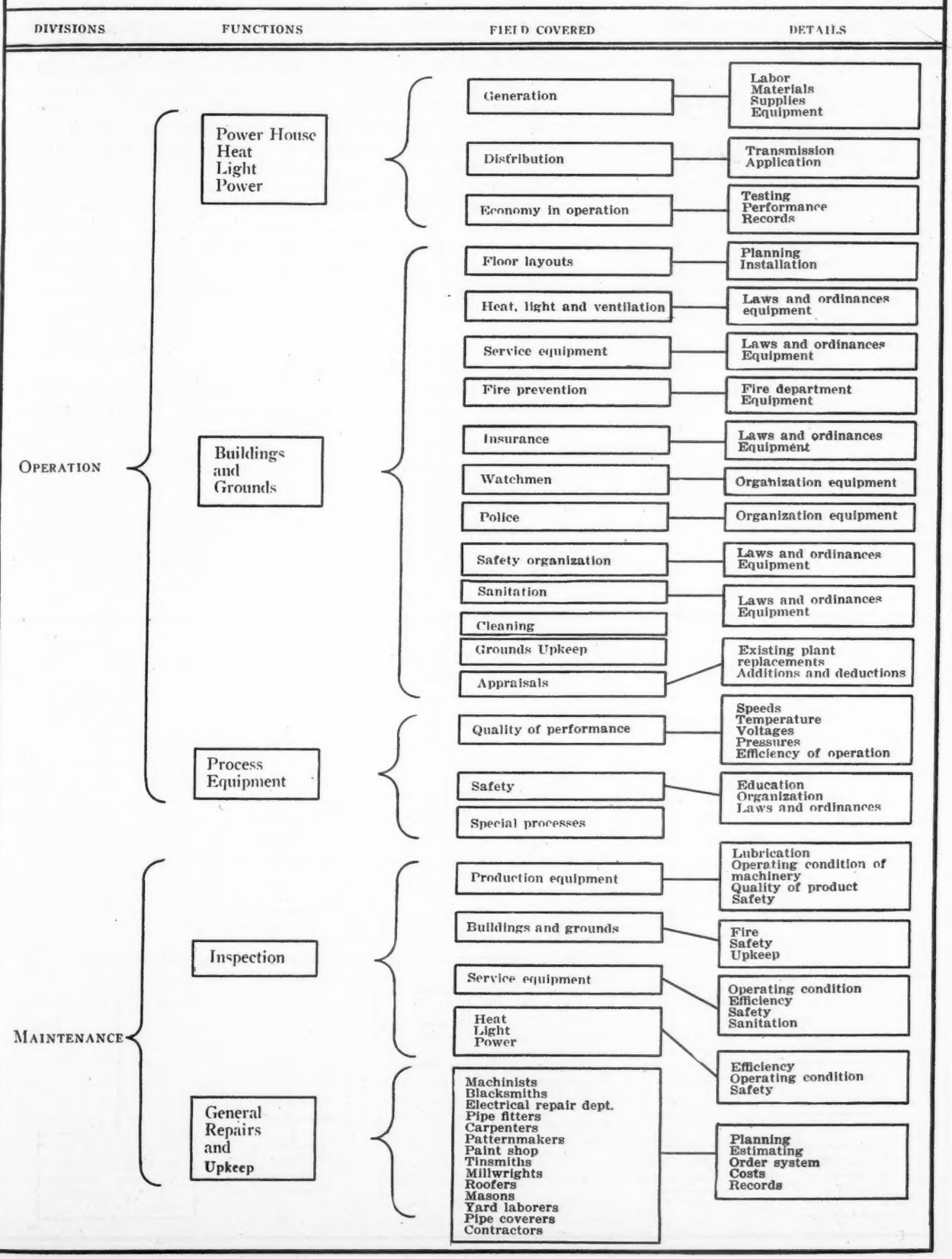


department are in one particular site. Here the plant engineer is directly responsible to the management, either through a corps of assistants, or personal contact, or his relationship with other departments in the business, consulting engineers and contractors. These require, however, personal supervision. Likewise are the engineering departments in placing designs, instructions, records and developments. There may be a man in charge of this specific department directly responsible to the plant engineer. This is, however, a staff function which comes under the immediate supervision of this responsible party.

The other two phases of organization are those of operation and maintenance, which may be supervised by assistants directly responsible to the plant engineer. These operating functions may be handled direct by the plant engineer in the smaller institutions. The major portion of operation and maintenance resolve themselves into the handling of labor and organization which carry out the orders of this department.

Chart II is designed for the larger plants where a central office is maintained and branch factories are controlled through a straight-line staff organization. The plant engineer is (in the same manner as on Chart I) responsible directly to the management, having two staff functions of contact with departments, consulting engineers and contractors on one side while the engineering department looks to him for control on the other. In a large plant these two branches would probably be covered by assistants with other men in operation and maintenance. There may be instances, however, when the plant engineer is directly responsible and supervises the operation of the two staff functions, but he has assistants for operation and maintenance.

Plan *A* illustrates an organization in a branch factory where the operation, maintenance and mechanical trades are headed up through one assistant and the power plant through its operating engineer, all responsible directly back to the plant engineering department.

Plan *B* shows a case where there is one man in charge of the branch plant, a master mechanic who is responsible for the entire operation of the maintenance and operating department in that branch. He, in one sense of the word is a plant engineer of that particular factory. As a result of this description, we classify him as a master mechanic who has direct charge of all phases of operation, being responsible for maintenance mechanical trades as well as engineering phase of power plant management. The operating engineers are directly responsible to him as well as the trades foremen in the maintenance department.

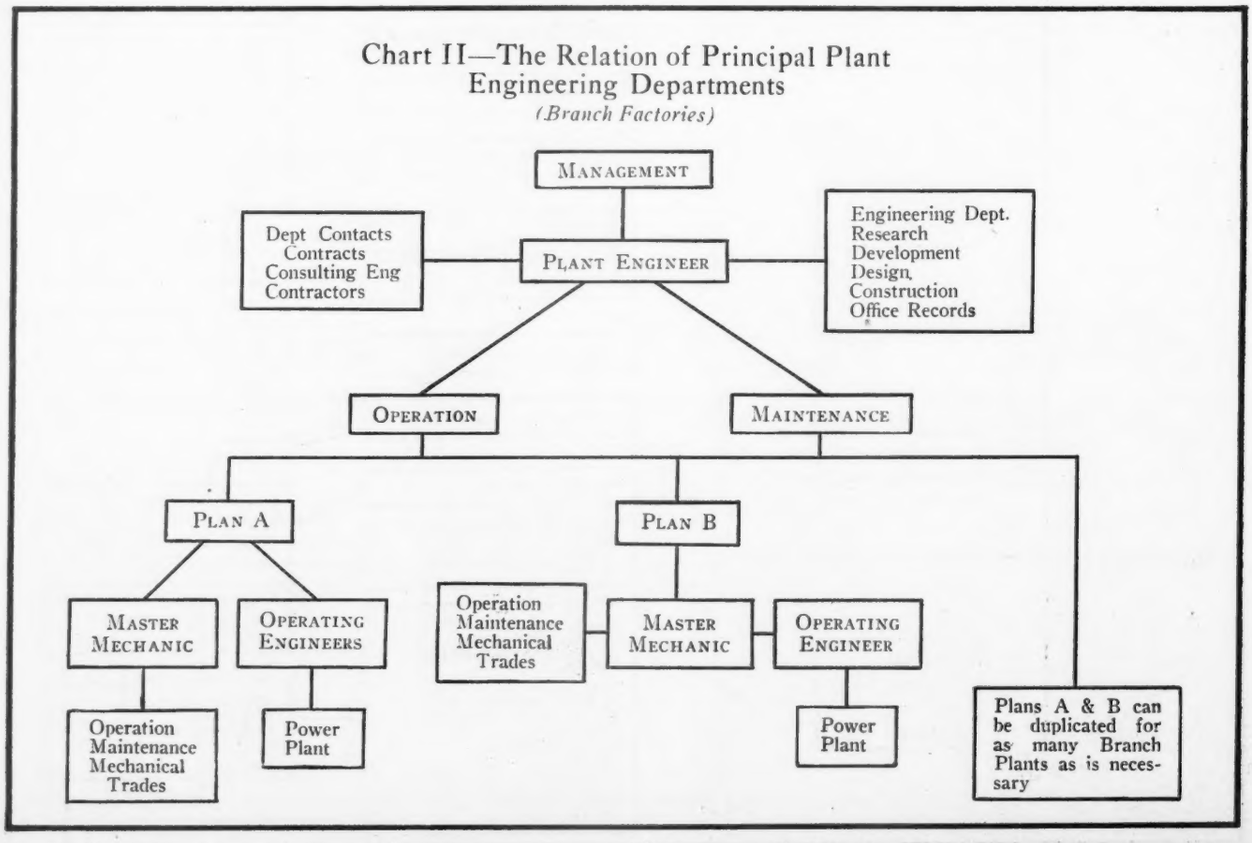
Plans *A* and *B* can be duplicated in as many branch plants as is necessary. These two charts give a very practical working arrangement for the organization of this department.

These function charts are not based on theory; they are founded on practical application of plant engineering problems which are appearing every day in the operation of twenty-five of New England's largest manufacturing institutions. They represent the thought and best ideas of men who have spent many years in this line of business. Men who are specialists in plant organization and operation, and who are familiar with all phases of engineering problems in extensive industries.

The Plant Engineers' Club who have developed this code feel that it is their duty to give to industry their experience in this organization plan. As plant engineers associations develop in various parts of the country, this phase of management will furnish a guide as to their possibilities for developing this branch of industry to a high state of perfection.

Chart II—The Relation of Principal Plant Engineering Departments

(Branch Factories)



Stop that Waste!

Hints for the proper storage and distribution

of Industrial Lubrication

By W. G. Ziegler

MOST of us do not realize the enormous amount of oil and other lubricants that are wasted each year on account of lack of proper equipment for their storage and distribution. Some of the equipment necessary to eliminate this waste, and thereby save money, will be described in this article.

The choice of lubricants should always depend on the service conditions. Foreign matter, such as grit and dust, contaminates the lubricant and seriously affects its quality so that every effort should be made to keep it clean. With proper facilities it is possible to keep the lubricants clean at all times.

The average plant using quite large amounts of oils will usually find it advantageous to buy in carload lots, as the savings possible often run as high as 20 per cent, by so doing. In order to do this, however, it is necessary to have large tanks that will hold more than a carload of each kind of oil that is used in large quantities, so that cars may be unloaded quickly when received.

All incoming oil from tank cars or any other source should be metered in order to keep accurate records of receipts. Each disbursement of oil should also be measured or metered and a regular stockroom record kept of daily receipts and disbursements, with a daily inventory of oil on hand.

Underground tanks may be merely put down in a hole in the ground and covered over with earth; or they may be housed in a concrete pit. When the tanks are installed in pits they should be raised up on piers in order to give free, air circulation under the tanks to prevent rusting.

All tanks should be oil tight and evaporation proof in order not to waste any oil. Seams in riveted tanks for oil are usually flooded with solder in order to prevent leakage and, for this reason, welded tanks are excellent for oil storage. All oil tanks should be vented to the atmosphere. This is often, more easily accomplished by having one vent pipe leading from a header that is connected to several tanks.

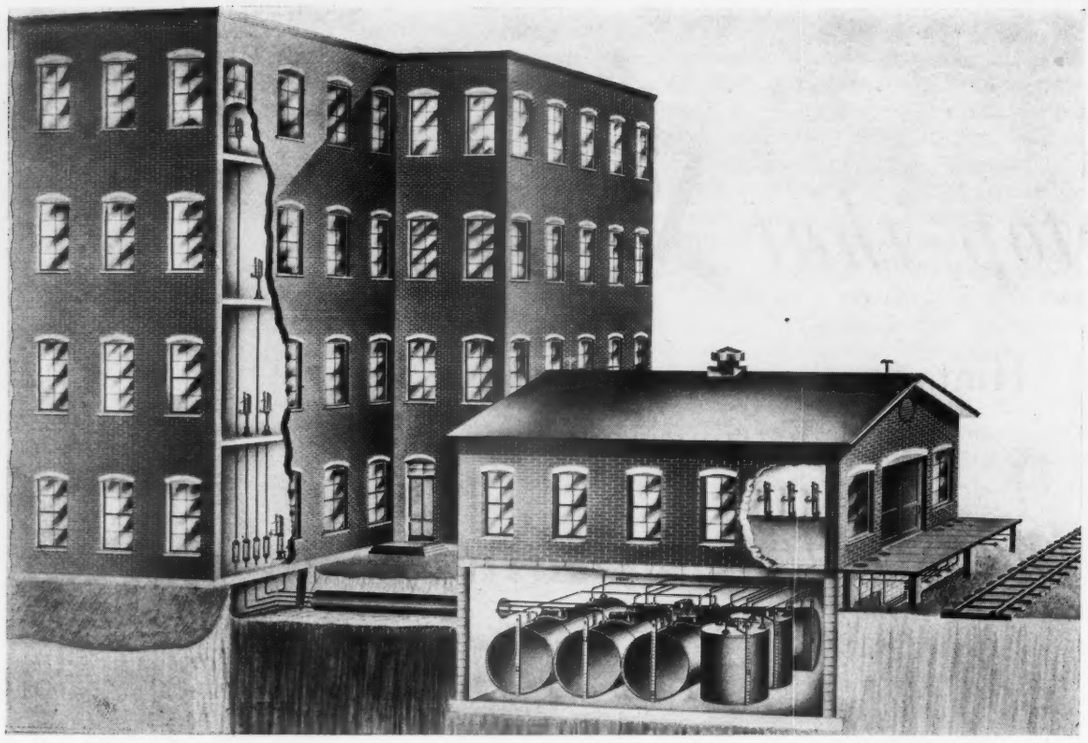
It is best to have tanks in duplicate with all piping arranged in tandem so that either one or the other tank may be used. This is extremely important when repairs have to be made on a tank or piping that supplies a system or a department requiring continuous service.

When oils are used in moderate quantities they are usually stored in tanks located in the basement of the oil house and still smaller tanks may be located in the oil house itself. Rectangular tanks take up less room and are therefore preferable to round ones where space is an important factor. The small tanks are economical of oil because the barrels or other shipping containers are drained as soon as they are received. As some shipping containers are received in a leaky condition, any further waste is avoided as soon as the oil is emptied into the storage tanks. The small

Oil service to remote places in the plant

tanks that hold a barrel of oil or even less than this amount are usually equipped with hand pumps and meters to measure the outgoing oil. These tanks may be used either in the oil house or out in the plant as they may be easily locked up. Similar tanks are mounted on wheels and may be used for delivering oil to the various departments throughout the plant. These wheeled tanks form a very convenient means for delivering oil in small quantities to remote places in the plant, as the oil may be dispensed with a minimum amount of labor.

The oil house should be conveniently located and at the same time have one or more tracks alongside so that tank cars may be unloaded promptly. The oil house should be fireproof with wire glass windows and fire doors. As cleanliness prevents the accumulation of any quantity of oil or waste on floors or in corners, there is slight chance of fire from spontaneous combustion if everything is kept clean. The man in charge of the oil house should keep accurate records of incoming and outgoing oil and this department may



CONVENIENCE IS EMPHASIZED IN THIS LAYOUT

The oil house adjoins the plant and the yard siding. Tank cars are drained to the basement storage tanks from which the lubricants are piped direct to the various floors of the plant. Hazards and waste are eliminated in the receipt, storage and distribution processes.

be a branch of the general stockroom if so desired. Oil should be delivered only on requisitions signed by the various foremen.

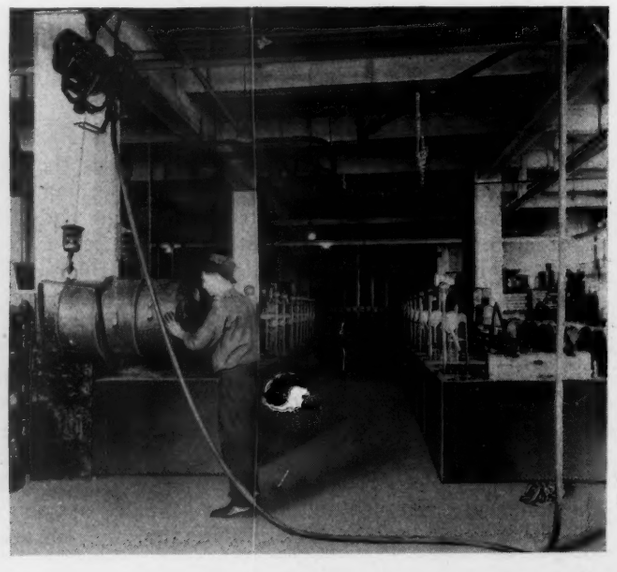
Where oil is used in large quantities it should be delivered wherever it is needed by pumping it through a suitable piping system from the storage point. Pumps of two general designs—rotary and reciprocating—are used for this purpose. Rotary pumps should maintain a uniform pressure on the discharge. They are usually direct connected to a motor that may be started and stopped by push-button controls at some distance. Reciprocating pumps may be either steam or motor driven. Hand pumps are used where only small quantities of oil are being handled. On hand pumps, a complete stroke of the piston usually displaces a measured quantity of oil and by attaching an indicating counter, all oil pumped is easily measured. For power driven rotary or reciprocating pumps a meter may be installed on the pipe line to record the oil pumped. These meters may be had in the automatic type that can be set to deliver any pre-determined amount and then shut off a valve.

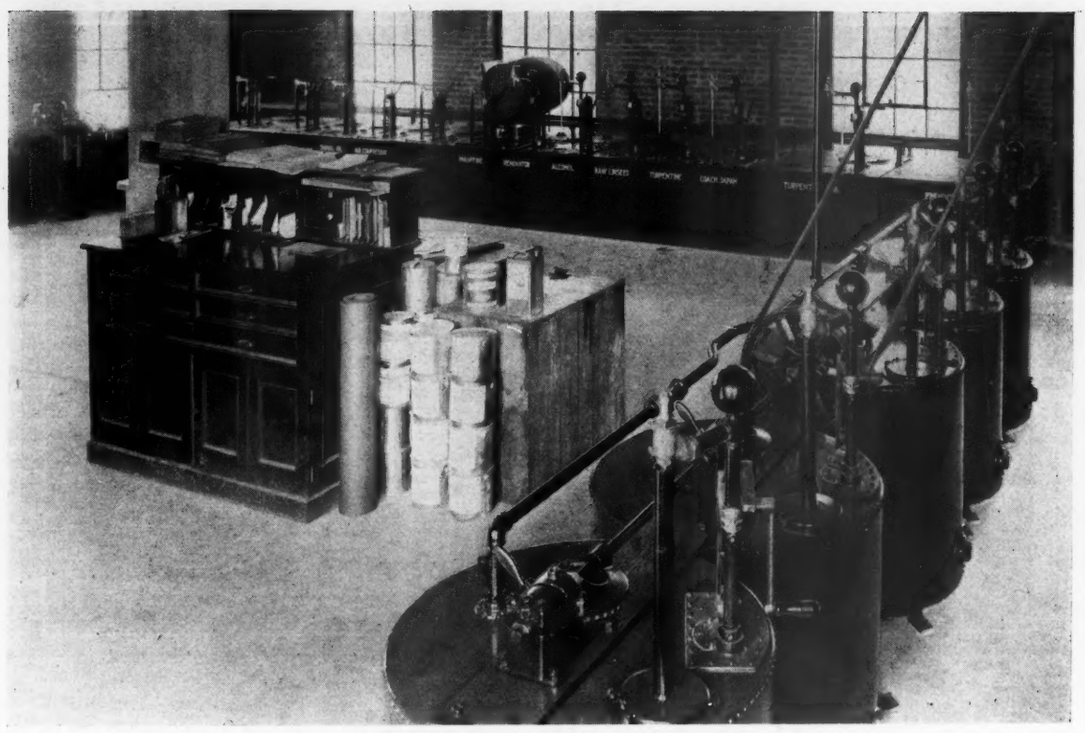
STORAGE METHODS OF THE PAST

Lubricants in the original containers are stored in the basement. At each container there is usually a gal on measure and a drip pan. The former is wasteful, in that smaller quantities must be approximated, and the latter is unsightly and conducive to contamination and fire hazards.

STORAGE METHODS OF THE PRESENT

Basement storage of lubricants used in moderate quantities. Rectangular tanks take up less room and they are economical. Waste is avoided by draining the original containers as soon as they are received. Hand pumps and meters measure the quantity of outgoing oil. An air hoist on a monorail system reduces the hand lifting involved.





STOCKROOM METHODS IN THE OIL HOUSE

The man in charge of this oil house keeps accurate records of incoming and outgoing oil. Requisitions are honored, only when signed by the various foremen. A daily inventory is obtained.

For continuous use of oil for lubricating bearings the pressure system is usually used. In this system the clean oil is pumped into a storage pressure tank or directly into the piping and delivered to the various bearings to be lubricated, the used or dirty oil returning to a filter from which it is again pumped out into the system. The piping should be oil tight and carefully laid out to avoid air pockets. Where oil lines pass through cold outside temperatures the pipe should be well covered or have a steam pipe alongside.

Where oil is required only intermittently it is sometimes best to install remote control valves in the various departments, these valves arranged to control electric pumps in the oil house. With this method the oil is usually used only once, but the oil may be brought back to a filter, either through pipes or in wheeled tanks, and then delivered to a storage tank to be used again when needed.

The quantity of oil on hand in the large underground and basement tanks should be shown by indicating gages in the oil house. Some gages are operated by floats and others operate on the hydrostatic principle.

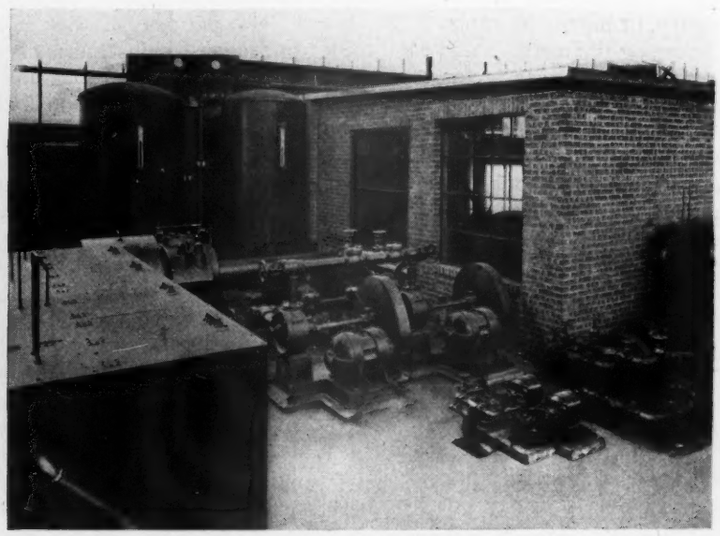
Greases are shipped either in steel drums or in barrels and when it is possible to use the grease direct from the drum or container by use of the pressure pumps this method of handling is very economical.

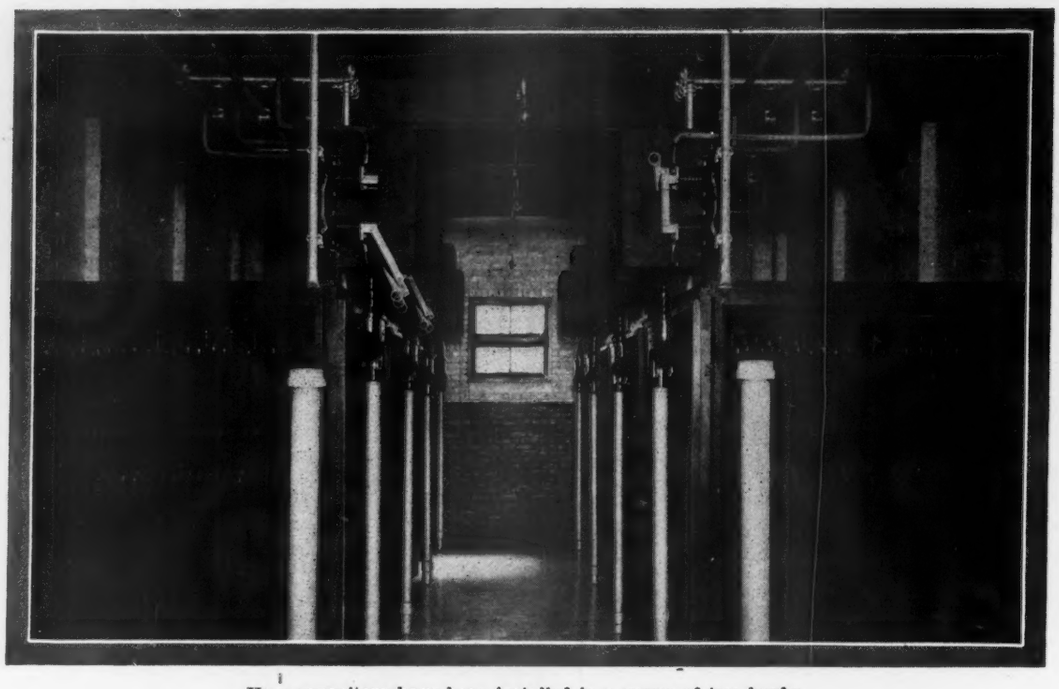
CONDITIONS GOVERN CHOICE OF STORAGE AND DISTRIBUTION EQUIPMENT

Oil is injurious to textile products, likewise lint will contaminate lubricants. Totally-inclosed containers satisfy both conditions.

EQUIPMENT FOR QUANTITY DISTRIBUTION

Pumps are used to send the lubricant through a suitable piping system under constant pressure. The return oil is piped to the reservoir beneath the floor from which it is pumped through the filters to the storage tanks.





Here capacitors have been installed in a group of two banks

What relief for the overloaded system?

R. C. MUIR

Assistant Engineer,
Industrial Department
General Electric Company

describes the use of CAPACITORS

For Power Factor Improvement

THE importance of power factor improvement is at the present time being given more consideration than ever before. Many factors make such improvement necessary, or highly desirable.

Among the methods and equipment available for power factor correction, so-called static or stationary condensers have come in for much discussion and attention. One reason for this attention is that only recently have manufacturers been able to offer equipment of this character that is attractive from the standpoint of price and reliability.

Although the above terms are widely used in referring to these devices, the Board of Directors of the American Institute of Electrical Engineers adopted the following definition in June, 1925: "A capacitor is a device used primarily because it possesses the property of electrical capacitance." Hence, the term "capacitor" will undoubtedly be in general use shortly, and to assist in standardizing it by usage, it will be used here.

The purpose of this discussion is to acquaint industrial plant men with the salient factors that must be considered in the selection and application of this equipment.

The industrial engineer may be confronted with the problem of improving the power factor of the electrical load for various reasons. Usually an increase in load is contemplated and the lines and transformers are already fully loaded; or it may be that no increase in load is contemplated, but that the power bill is high, the lines or transformers are overloaded, or the voltage regulation is poor. The probabilities are that improvement in power factor will permit of additional load without increasing line or transformer capacity. Also, it will reduce the power bill, improve the voltage regulation, or reduce the current load on transformers and lines to a safe value.

We will assume that the engineer has made the necessary analyses and that everything that is permissible or feasible in that particular plant, has been done in the selection of induction motor ratings or by the use of synchronous motors to obtain high power factor. We will also assume that capacitors offer the best solution of the problem, or of that part of the problem which still confronts him after other changes have been made. He has arrived at this decision for various reasons, among which any of the following may be found:

(1) The plant is of such nature that it is extremely desirable to bring about the improvement in power factor with the least possible disturbance;

of existing operating conditions. Replacement of induction motors by synchronous motors may disturb production and may involve the retirement of perfectly good motors, which procedure might prove to be more expensive than the addition of capacitors. Furthermore, the operators may be accustomed to running the plant as it exists, and the addition of capacitors will not affect operating procedure in any way.

(2) No construction expenses will be involved for foundation or other mechanical changes, as the capacitors can be installed in convenient locations. They can be distributed to suit the conditions, either in one main group on the bus or in smaller groups at advantageous locations, or even at the terminals of the motors themselves.

(3) The plant, even though it is just being planned, may be of the type where the motor applications are such that synchronous motors cannot be used to advantage, and the load conditions may be such that the desired power factor cannot be obtained by careful selection of induction motors. In many plants the trend is toward the use of individual drive, which offers many advantages in production, shop arrangement, and efficiency, all of which overbalance the saving in first cost of using larger motors for group drive. This trend frequently makes the capacitor the most efficient means of improving the power factor.

Coupled with these reasons, he has also taken into consideration certain other advantages of capacitors, which might be summarized as follows:

(1) No attendance is required.

(2) Losses are less than 0.5 per cent of the kilovolt-ampere rating of the capacitor.

(3) They may be applied directly at the source of low power factor, thereby reducing line losses to a minimum.

(4) Flexibility as to sizes, which facilitates additions to take care of increased load at low power factor.

(5) Extreme flexibility as to location and installation. No special foundations are necessary and floor space often is not used.

(6) They meet the Underwriters' requirements without special provisions, such as housings or vaults.

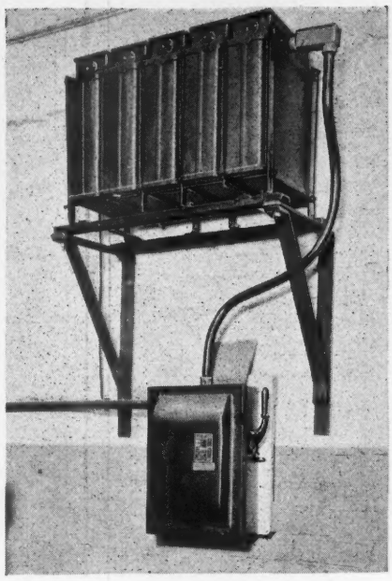


FIG. 2 — CAPACITOR GROUP INSTALLED ON A FEEDER CIRCUIT IN A MACHINE SHOP
These units are 15-kva. capacity and operate at 550 volts, three phase.

Possibly in his first analysis he has arrived at a decision as to how the capacitors are to be installed, as there are several alternatives available. Thus, one large capacitor or group may be installed on the bus, as in Fig. 1; smaller capacitors or groups may be placed at advantageous locations, as in Fig. 2; or single capacitors or groups may be located at the terminals of the motors, as in Fig. 3. Again, the engineers might decide upon a combination of the small group and the individual motor installation. Before making this decision, however, he must take into consideration many factors bearing upon the problem.

Generally speaking, the large capacitor or group is desirable from the standpoint of economy in first cost and cost of installation, and has been generally employed. There are cases, however, where the application of capacitors of small size, either to the individual motors or to small groups of motors, proves to be the most satisfactory solution of the immediate problem.

The advantages of the application of capacitators to individual motors are:

(1) Absolute assurance of power factor to be obtained, as the capacitor and the motor operate as a unit with a definite power factor characteristic.

(2) Improvement of voltage conditions at the motor itself, under both starting and operating conditions.

(3) Lowering of cable losses with accompanying advantages, such as the use of smaller cables for a particular motor capacity.

The disadvantages of applying the capacitors to individual motors are:

(1) The lack of capacitor diversity factor, which results in a higher total capacitor capacity for the plant, with resulting higher first cost.

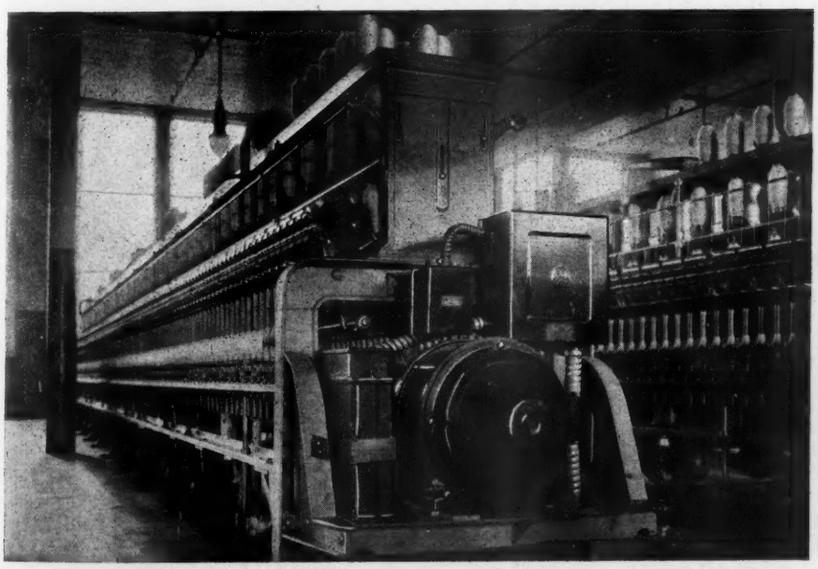
(2) The objections to having any more equipment than is necessary in the vicinity of the motor or machine which it drives.

It might be well to discuss some of the above points more in detail.

Considering the first-mentioned advantage, it will be interesting to note from Fig. 4 that the combination of a capacitor and a squirrel-cage induction motor makes an exceedingly satisfactory high-power-factor unit.

The second advantage might be

FIG. 3—USUALLY IT IS NOT DIFFICULT TO INSTALL A CAPACITOR AT THE MOTOR TERMINALS
The unit shown here is of 3-kva. capacity, operating at 550 volts, three-phase, in a textile mill.



particularly important in some cases where difficulty is being experienced with low starting and low pull-out torques of the motor, both of which are due to low voltage, as both are in proportion to the square of the applied voltage. It might be that the voltage regulation is so bad that there is an actual loss in production, due to reduced motor speeds. Contacts in control devices might be overheating or fuses blowing, due to the excessive current required because of low voltage. On the other hand, the lines to the motor might be of such capacity that conditions of this sort do not apply, in which case little weight should be given to this advantage. In this connection, Fig. 5 will be of interest as it gives an indication of what may be expected in the way of voltage drop at different values of power factor on the average low-voltage circuit.

The same comments as above might apply to the third advantage; in this connection Fig. 6 will be of interest as it shows the increase in energy load that can be carried by a particular cable with improvement of power factor. The engineer should make some calculations covering the power losses in circuits with and without capacitors installed at motor terminals. It might be that the runs are so short and the cables so large that losses are negligible.

Considering the disadvantages of applying capacities of the individual motors the first one might be sufficient to decide the whole matter, as the plant may have a great many motors which are used only a small part of the time; hence, the first cost of capacitors installed at each individual motor might be prohibitive.

The second disadvantage would not be particularly marked in many cases, as space could be found in the driven machine where the individual capacitor could be mounted. There are many cases, however, where the space factor might be the deciding feature.

It is unfortunate that we cannot put down in writing, definite rules by which these matters can be decided. The best that can be done is to point out the considerations involved so that the industrial engineer, in making his analyses, will not overlook certain factors bearing upon his problem.

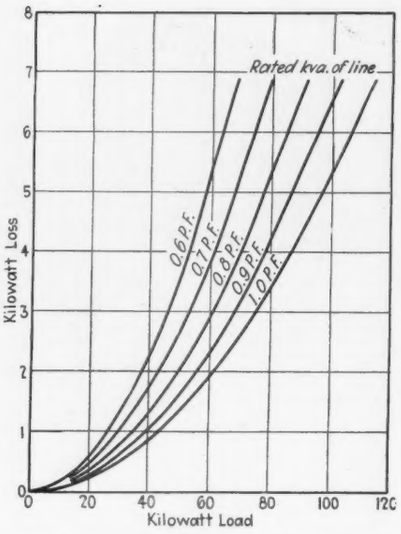


FIG. 6—LINE LOSSES DECREASE AS THE POWER FACTOR GOES UP

These curves show the line losses under different values of power factor on a three-phase, 60-cycle circuit composed of No. 0 wires, spaced 9 in. apart, delivering 440 volts at the motor.

First Arc-Welded Structural-Steel Building In the West

THE first building west of the Colorado River, to have arc-welded joints throughout has been erected at Denver, Col., for the Colorado Compressed Gas Corporation and is another step in the successful application of arc-welded structural steel to building operations.

This arc-welded structural-steel building is the first unit of the manufacturing plant of the Colorado Compressed Gas Corporation, manufacturers of acetylene gas. In the design of the building it was necessary to consider the requirements of a building wherein such a product is manufactured.

The enclosure of such a building should be of material that will afford the best heat insulation and at the same time not possess the characteristics of a rigid structure, such as would result in the use of masonry for the enclosing walls. To meet these requirements it was decided to use a special asbestos-protected metal manufactured under the Robertson process.

The Midwest Steel and Iron Works, Denver, Col., erected the structural steel and in doing so electrically arc-welded every joint in the entire structure using a 200-amp. Westinghouse portable arc welder. Twenty tons of steel were used in the erection. It represents an outlay of approximately $50,000 and was completed in eight and one-half days.

FIG. 4—POWER FACTOR CURVES OF SQUIRREL-CAGE MOTOR

The motor was of 15-hp. rating and was operated at normal voltage with capacitors of various rating.

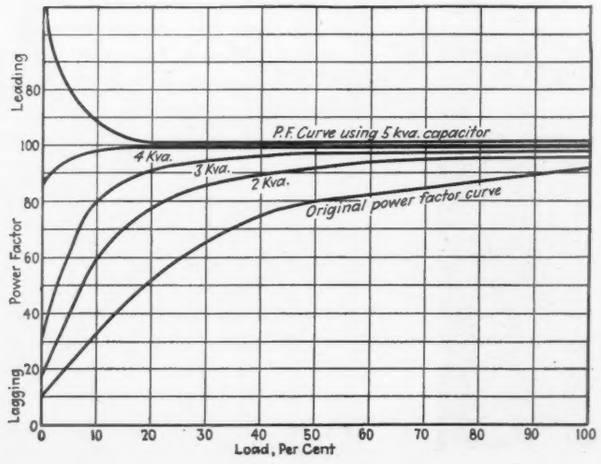
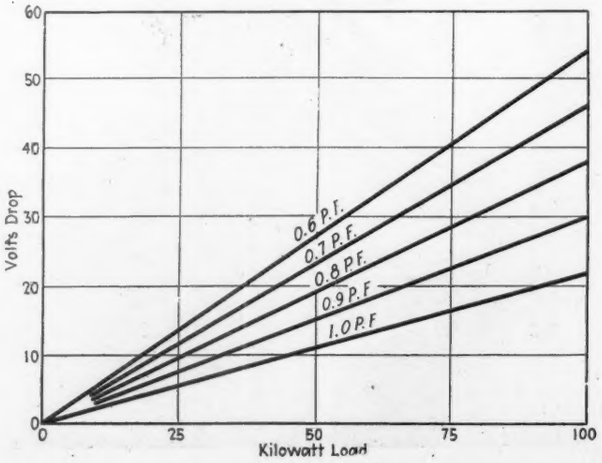


FIG. 5—THIS SHOWS HOW VOLTAGE DROP VARIES WITH POWER FACTOR ON A 60-CYCLE CIRCUIT

These data were obtained on a circuit of No. 0 wire, 1,000 ft. long with 9-in. spaning. Voltage at the motor is 440 volts.



General layout of the Haverstraw, N. Y., plant

Bringing the Stone Crushing Plant *Up-to-date*

By F. W. Westbrook

DIVERSITY in the applications of electrical power in a modern stone crushing plant illustrates in a remarkable way the important part that proper selection and installation of electrical equipment play in successful mechanical handling. It is probably safe to say that in few other industries has the mechanical handling of materials been carried to such lengths as in the newest crushed stone plants.

This point is well illustrated in the Haverstraw plant of the New York Trap Rock Corporation, where 3,500 cubic yards of crushed stone are produced per day with the help of only 80 men, a large proportion of whom are occupied only at the beginning and end of the operations. This plant has been in operation about one year and represents the very best electrical and mechanical practice in its field; therefore, a consideration of the electrical features will be helpful to operating men in other industrial plants.

The plant has been constructed on the slopes above the Hudson River and as the stone passes from one operation to the next it steadily progresses down hill. The drilling is done by electrical well drills and after blasting, the rock is picked up at the base of the cliff by electric shovels and loaded into motor trucks. These are dumped into the primary crusher, whence the rock travels by gravity or belt conveyors to two other crushers and then through a series of screens to sort out the different sizes. Finally, the various sizes are taken from under the concrete storage silos on a series of belt conveyors, passed through a washing operation, delivered to a chute on the dock, and loaded on to barges.

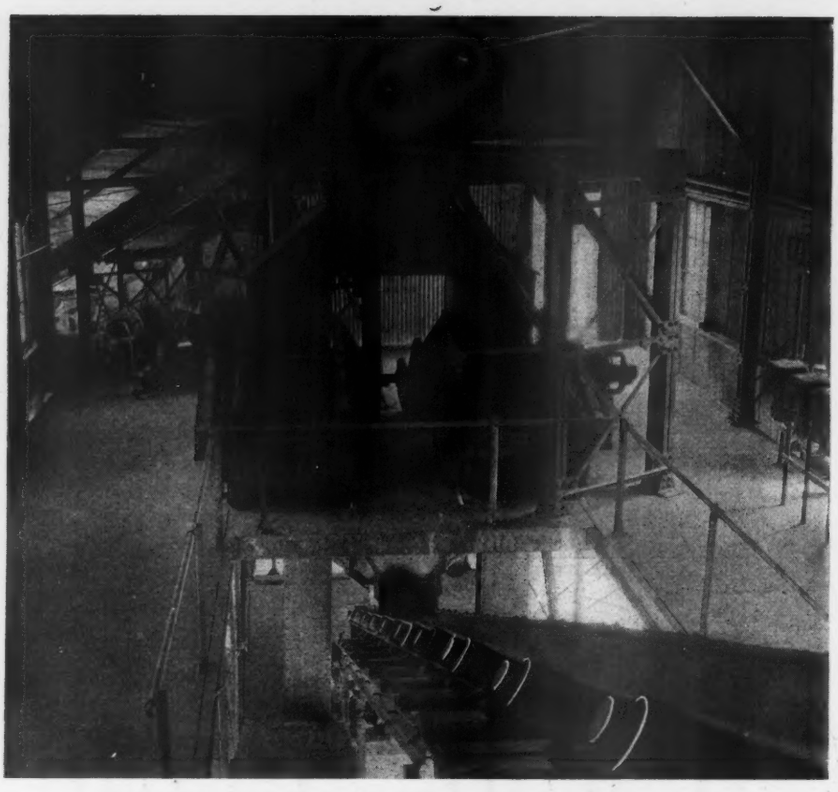
All of the machinery is operated by individual motors.

The connected load is 2,465 hp. and the plant power factor is about 88 per cent, which is extremely good considering the sudden changes in loading to which the shovels, crushers, and to some extent the screens, are subject. Central station current is supplied at 33,000 volts, three phase, 60 cycles, and is stepped down to 2,200 and 440 volts by three 500-kva. transformers.

The substation is located in the central part of the plant. Lightning arresters are placed on the lines at every bank of transformers, including the 2,200/440-volt units, as well as on the buildings where the power feeders enter.

The electric shovels build up such high peak loads at times that the drop in voltage is excessive unless a very large supply line is used. In this plant, current is transmitted about 1,000 ft. to the various crushers and shovels. One line of 400,000-circ. mil cable supplies current at 2,200 volts for the 1,135 hp. load in crusher motors. This line supplies only the crushing equipment and the drives of the conveyors that carry the stone from one crushing operation to the next.

A separate 25,000-circ.mil cable serves the two Marion No. 37 electric shovels, each driven by a 75 hp., 3-phase, 440-volt motor, and one Bucyrus No. 100-B electric shovel having a 165-hp., 2,200-volt induction motor. There are also two 225-hp. synchronous-motor-driven air compressors on this line, making a total load of 765 hp. on these feeders. This arrangement gives very satisfactory operation and takes care of the high peaks reached by the electric shovels without interfering with crushing equipment. It has been determined by tests that the electric shovels will run as high as 400 per cent load at times. If these were connected to the same lines as those which supply the crushers, very large conductors would be required in



CATARACT GRIZZLIES FOR SEPARATING THE DIFFERENT SIZES OF CRUSHED STONE

These are driven by 25-hp. motors through speed reducers. The motors and transmission are totally inclosed to protect them from the stone dust.

order to avoid trouble due to voltage drop.

All the well drills are driven by 15-hp. variable-speed motors. The variable-speed type was selected because experience has shown that more speed in drilling can be obtained, with quite a saving in rope, if the operator is able to change the speed of his machine as required.

Feeders for the shovels and drills are run on poles, and taps are brought down and terminated at various convenient points where the flexible cables supplying the machines may be attached. As shown at right the wires for the 2,200-volt Bucyrus shovel service are brought down to a low crossarm, passed through fuse boxes and then through a General Electric oil switch. On the service side of this switch the wires terminate in a Crouse-Hinds receptacle; the flexible service cable on the shovel terminates in a plug. The other shovels are served in the same way.

The flexible cables are of the Rome superservice cord type, having three rubber-insulated conductors and a heavy outside rubber jacket or sheathing without braid. This type of cable, experience has shown, gives much better service than any other so far available.

The well drills are served in much the same way except that in this case the fuses and oil switches on the poles have been omitted. The line wires are supported on brackets on the poles, and the taps are brought down in conduit furnished with a gooseneck at the top and a Crouse-Hinds connector at the bottom.

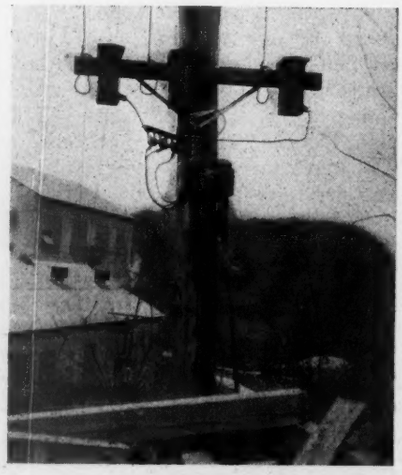
Coming to the inside equipment, crushing is the first operation encountered. The powerful primary crusher is driven by a 200-hp., slip-ring motor. The control apparatus for this motor is very rugged and has grids of the constant-duty type. Very often a bad block in the crusher is more easily broken by slowing down the motor than by keeping it at full speed, for this reason heavy, rugged apparatus was installed. Above the jaw crusher a 25-ton electric crane with a 5-ton auxiliary has been installed for handling the heavy parts of the machines and breaking bridges in the crusher. All of the crusher motors are reversible because blocked crushers can usually be started by throwing the switch to the reverse position, backing the crusher up a little, and then going forward again.

The primary crusher discharges into two 20-in. gyratory crushers driven by individual 150-hp. synchronous motors which are connected to the crushers through 36-in. magnetic clutches. The stone discharges from these crushers onto a conveyor belt which runs over a 36-in. magnetic separator to remove tramp iron.

Two more crushing operations are necessary to reduce the stone to commercial size. The first of these is accomplished by 10-in. gyratory crushers, each driven by a 100-hp., direct-connected slip-ring motor. For the second crushing Newhouse high-speed crushers driven by 60-hp., 1,165-r.p.m. motors are used. These motors are of the vertical, ball-bearing type and are particularly well adapted to the very heavy service. Associated with this crushing equipment there are two screening operations to return over-sized rock to the crushers, as well as several belt conveyors to transport the stone to the proper machines. Each machine has its individual motor. It has already been stated that all the crushing and associated machinery is supplied with power from one set of feeders and that the drills, shovels and air compressors are supplied from another independent set of feeders. It has also been pointed out that in both of these services the machines are subject to sudden and violent fluctuations, varying from no-load idleness to 400 per cent load. What such conditions, unavoidable in this kind of work, would do to the plant power factor if nothing were done to correct it, is not hard to imagine. What the power company would do about the rates and penalties is no more difficult to surmise.

THE ELECTRIC SHOVELS ARE SUPPLIED WITH POWER FROM STATIONS LIKE THIS

The flexible service cable of the shovel is plugged into a Crouse-Hinds receptacle attached to the leads from the oil switch.

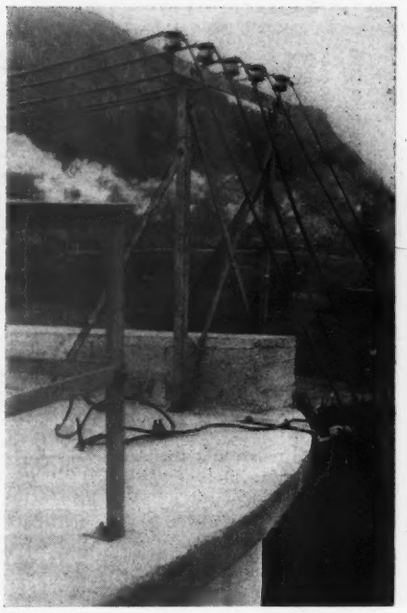


The power factor is kept up to 88 per cent, as stated near the beginning of this article by the use of large synchronous motors in each circuit. Thus the feeders supplying the shovels and drills also supply the two 225-hp. synchronous motors that drive the two compressors; the feeders for the crushing department supply the two 150-hp. synchronous motors driving the two large secondary gyratory crushers. All of these synchronous motors operate at 2,200 volts. Most of the other motors use 440-volt current and have individual transformers. Thus, by exercising a little engineering skill the power factor, with its resulting economy in the power bill, has been maintained at a high level in a very simple manner.

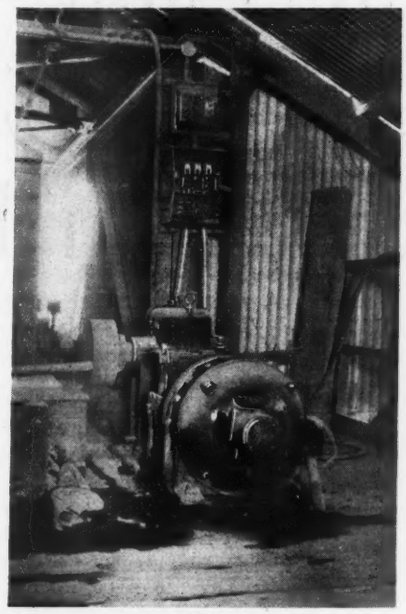
In the screening plant proper the crushed stone is sorted out into the various commercial sizes. A great deal of mechanical handling by means of belt conveyors is involved in this department. The first step is to convey the mixture of sizes from the crushing department to the screening department on a conveyor 30 in. wide and 860 ft. long between centers. It is 70 ft. lower at the discharge end than at the upper end. For this reason the conveyor would run away when loaded with stone, unless prevented from doing so. Hence, regenerative braking is employed, so that when the conveyor speeds up and drives the motor above synchronous speed, the motor acts as a generator and pumps power back into the line, at the same time holding the conveyor down to practically its normal speed. When the conveyor is fully loaded about 7.5 kw. is returned to the line. If for any reason the switch were opened when the conveyor is loaded it would naturally start to run away; this is prevented by a solenoid brake on the motor shaft, which immediately sets as soon as power is cut off from the motor terminals. A 20-hp. motor is used on this drive.

When this belt conveyor was originally installed the motor was placed at the lower end, so that when the belt was loaded with stone, with the motor acting as a brake, the belt would try to run up on the pulley at the lower end. As a result the bottom of the belt was very tight and the top was slack. This caused excessive sagging between the rollers, and a very objectionable bumping at each roller as the stone passed down the grade. By placing the motor at the upper end of the conveyor this difficulty was completely overcome.

The same principle has also been applied to the conveyor belt for carrying the sized stone from the various storage silos to the washing plant. This belt is 600 ft. between centers and has a drop of about 60 ft.



FEEDERS FOR THE VARIOUS BUILDINGS ARE SUPPORTED ON A LIGHT ANGLE-IRON FRAMEWORK



ONE OF THE CONVEYOR MOTORS WITH ITS REDUCTION GEAR AND STARTING EQUIPMENT

DRIVE FOR ONE OF THE SCREENS IN THE CRUSHING PLANT

The transformers at the left step the 2,200-volt supply down to 440 volts for this and several other motors.

In screening the larger-sized stone revolving screens are used, but for the smaller sizes electric vibrating screens operated at 110 volts, 15 cycles, are employed. A separate motor-generator set is used to generate this 15-cycle current. This set is located at a central point, a heavy supply line being run from the machine to the various screens where each vibrator is tapped off.

All of the conveyors have individual motors and are driven through De Laval worm reduction gears. All of the motors in the plant, except the synchronous motors, have push-button control. Stop buttons for the long conveyors are located at several convenient points so that the conveyors may be stopped instantly in case of an emergency.

All conductors have been run through conduit, the latest designs of control equipment and switches have been used and every precaution has been taken to secure safe and continuous operation. Motors are blown out every day and the oil changed every two weeks, every week in some cases. This careful attention is necessary not only on account of the severe service condition, but because the dust, and in some cases the moisture, in the buildings and tunnels through which the conveyors pass, would soon cause trouble.

An electric truck and trailers in a meat packing plant

Meat Packing Plant

Rivals Railroads in its

Transportation Facilities

By Harold J. Payne

IN ORDER to bring out the extent to which waste that formerly existed in transportation in this industry has been eliminated the experience of the plant that is now considered to be the pace-setter in this work will be outlined.

In this plant distances between department run from 200 to 300 feet and up to several thousand feet. The problem is complicated by the necessity of maintaining a low temperature in many work rooms that are dependent upon an adequate transportation system for a regular supply of raw material and for facilities to remove their products.

This plant made its first step in 1918 when a single storage battery tractor and a small number of trailers were purchased. At that time most of the elevators in the plant were of insufficient capacity to carry the tractor with its train, the elevated tramways that did exist linking up various buildings were inadequate, necessitating much use of both the elevators and first floor runways, and much prejudice existed, both on the part of various foremen and on the part of the unskilled workers. Even under these handicaps, the savings made were so satisfactory that it was decided to augment the original equipment with more units.

It soon became apparent that if the necessary tramways and elevators could be made available very nearly all of the trucking involved in handling 150 carloads of out-bound product per day could be taken care of with the electrics. After repeated try-outs in the various types of service required to effect this change, the necessary appropriation was made, amounting to nearly $1,500,000. Consequently at present the tramway system connecting the third floors of all of the buildings in the plant is complete and five large elevators, each having a capacity of one tractor with four trailers, have been built at strategic points, mainly in buildings of several stories, each of which is served by the tractors.

The entire layout is on the same basis as that of a railroad serving scattered communities. Main trunk lines extend in four directions from a central assembly and transfer point. The tramways mentioned center at this hub, and a nearby elevator having a capacity of 15,000 pounds, provides a means for quick transfer to one of the main shipping points located almost directly beneath this hub. Feeder lines run from the main lines to buildings located off of principal avenues of travel.

Rolling stock and motive power consist of 1,500 standard steel chassis, caster-type steel trailers, having platforms 3 ft. by 6 ft. and 23 tractors. Side gates and end gates for the platform trailers convert them into box cars for all practical purposes. Deep metal trays are used for carrying liquid or solid compounds—converting the standard chassis trailer into a tank car by this expedient. A two-bar cross hitch is used for coupling in order to steady long trains on the curving grades (up to 5 per cent) some of which are several hundred feet long. Trains of as high as 32 trailers have been pulled successfully although from 4 to 8 trailers make up most of those pulled.

The organization developed to take care of the transportation equipment, handling its maintenance and disposi-

tion, is unique. A central garage, located on the same level as the tramway system is the home of all the tractors. Steering knuckles and motor bearings are lubricated daily; wheel bearings are greased weekly. During the two months in winter when operations in the plant are relatively slack, all of the equipment is thoroughly overhauled, worn parts are replaced and, usually, tires are renewed.

In addition to carrying a pro-rated share of garage overhead, that includes labor of charging, power, heat and rent, all repairs made on a given tractor are borne directly by that unit, Each driver uses the same machine every day. In this way responsibility for its proper care is definitely allocated. Because of this close supervision and consistent maintenance, the oldest tractors in the plant, now nine years old, are giving service which is practically as satisfactory as that obtained from the last tractors to be put in operation. That such a policy is good business is pointed out by the fact that the total average fixed charge against each tractor, aside from the time of its operator, is less than $0.60 an hour or $4.80 for an 8 hour day.

At the central garage mentioned requisitions for equipment are received. Any department wanting service, pays an hourly rental charge for each unit of equipment used. This charge is based on cost but being definitely allocated in this way, the transportation department is protected against idle time for any of the tractors. When a driver has finished a given job, he either calls up or returns for further orders. In this way every tractor out is kept busy 95 per cent of the time, and since actual savings made depend largely upon the hours of active service performed the system is found to work out to excellent advantage.

In a plant so large, and with such varied operations, it is difficult to arrive at an accurate estimate of the saving effected by each machine. Block railroad cars no longer delay the prompt transfer of material from one section of the plant to another. Speeding up all along the line has been general—sometimes definitely decreasing the exposure of perishable products to heat thus making possible higher quality when finally shipped.

The photographs indicate more clearly than words can, how the fleet ties into the wide diversity of operations necessary to the conduct of such a plant. The flexibility of the storage battery tractor method is clearly brought out in this way. One of its greatest advantages from an efficiency point of view is that it is capable—without modification, of fitting into varied activities. This makes possible a maximum earning power. Whereas fixed material handling equipment pays dividends only when work is to be done where it happens to be located, the mobile unit can move quickly to any point in the plant, working for practical purposes, between almost any points that the hand truck can work.

As unskilled labor becomes increasingly scarce through restricted immigration, and as competition forces further the necessity for eliminating all avoidable waste in production, the use of mechanical "labor-aids" in the form of modern material handling equipment is certain to become increasingly general. Just as the introduction of power driven equipment has greatly cut down on the per unit cost of production for the skilled worker during the past twenty years, energy must be mechanically harnessed during the years ahead to allow the ordinary laborers to accomplish more in every working day.

This story of developments in this direction in one of our barometer industries is significant in this respect. Definite strides have been made; others are following rapidly. Throughout the range of industry, where transition is made from the old to the new, in doing the non-productive jobs such as handling, the storage battery tractor and truck are already found. As time goes on, they will be found to a greatly increased extent.

AN ELECTRIC TRUCK HANDLING TRAILERS LOADED WITH BARRELS ON AN ELEVATED ROADWAY IN A MEAT PACKING PLANT

The meat packing industry has become famous for utilizing every portion of the pig except the squeal. Development of new products and of processes and equipment requisite to their efficient production has been proceeding rapidly for the past twenty years. Only recently, however, has a concerted drive been made to bring the links connecting the various slaughtering, packing and manufacturing activities up to the same degree of efficiency that has come to mark the conduct of these various inter-related enterprises.

Since every unit of product shipped has to be handled several times, transportation within the larger plants involves the daily movement of thousands of tons of finished products such as fresh meats and smoked meats which include hams and bacon, also shipments of lard, sausage, butterine and many other items. Ice for cooling refrigerator cars, byproducts from killing departments and feed for the sustenance of live stock also have to be handled in large volume.

In the past, horse drawn carts, hand carts, railroad cars and hand trucks were used exclusively for maintaining the necessary flow of product through the various steps in process. Despite the difficulties involved in satisfactory operation of such a system, up to within a few years the project of installing the modern layout that would make possible the use of efficient, standardized handling equipment was felt to be impossible. High indirect labor charges, that were involved in doing this work under the old system, finally led, however, to the experimentation with a class of equipment that had previously come into considerable use in other lines of industrial handling.

INDUSTRIAL ENGINEERING

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INDUSTRY ILLUSTRATED

Electrical, Mechanical and Plant Service in Industry

G. A. VAN BRUNT, *Editor*

Published by the McGraw-Shaw Company

New York, February, 1928

William Staniar Joins Staff of Industrial Engineering

TOO little really accurate knowledge has been available with respect to mechanical power transmission; and developments in belting, in short-center drive equipment, in bearings and a host of other appurtenances, have been progressively swift and revolutionary in recent years.

Most of you, actively concerned with bettering the efficiency of your mechanical power transmission systems, are aware of this lack of up-to-the-minute, authentic information. And most of you require no introduction to William Staniar, who joins our staff in the capacity of Consulting Editor, and whose articles on mechanical power transmission problems will hereafter appear exclusively in the pages of INDUSTRIAL ENGINEERING and its sister publications.

Mr. Staniar is recognized as the foremost living authority on mechanical power transmission, and has the happy faculty of being able to put into his writings, for the benefit of his readers, the wealth of practical knowledge accumulated during his years of experience as Belting and Transmission Engineer for E. I. du Pont de Nemours and Company and its subsidiaries. In this capacity, he has charge of power transmission in 54 plants of the du Pont and General Motors Corporations. Mr. Staniar is also chairman of the Advisory Board of the Power Transmission Association, and is a well-known contributor of articles on his chosen subject to the technical press.

Spare Parts Are Insurance Against Production Delays

THE part that proper inspection and maintenance play in minimizing production delays due to failure of equipment is too well known to require discussion. Careful attention to the condition of equipment will always pay handsome returns in the way of increased reliability of service and lower repair costs.

Nevertheless, well-organized maintenance schedules can not entirely prevent occasional breakdowns, to say nothing of the natural wear and tear of service which ultimately lead to the failure of many important parts.

Money invested in a well selected stock of spare parts should not be regarded as idle capital, but rather as the premium on very effective insurance against avoidable production losses. Savings that can be made by having needed parts available within a few minutes may easily amount to many times the annual interest charges on the invested capital represented by these parts.

Experience will prove that a few hours spent in checking up your spare parts stock, to make sure that it is adequate to meet any probable demands, have been used to excellent advantage.

Safety Inside the Fence

CURIOSITY oftentimes leads to enlightenment. The fact that so many employees at "Armco" found interest in studying a safety signboard inside the fence brought about inquiries on safety that led to the statement by George M. Verity, president, American Rolling Company at Middletown, Ohio:—"In the electrical department which employs several hundred men, we have not had an accident in over ten years. Other departments as groups engaged in hazardous occupations have enviable records also, and the number of total accidents each year is steadily decreasing." In trying to find the reason that would justify this statement, other observations were made in and about the mills.

Above the gates, one observes a row of inclosed lamps on which numbers have been stenciled. These numbers correspond to the various departments referred to on the board that was being studied by the men. A lighted lamp indicates an accident in that department. The "big board" scores the total number of accidents to date for each department and many departments have clear records for as many as 92 days.

In the mill, signs with the usual precautions were observed, but phrased in terms that the men understood. One department labored noticeably under the chaffing of an adjoining department for losing the safety honors in competition. The winners took the prizes and the good natured privilege of installing new signs amidst the conquered that constantly reminded them of their defeat. Humorous as they are, these signs will remain until some other department takes their place in defeat.

Picture for yourself, the keen rivalry between men for department safety records at "Armco," where each group contributes its share of co-operation to the whole. They are playing the game of safety with something more than lives and limbs as penalties. There is spirit, mutual co-operation and understanding. In every other industry safety can be made a game if there can be these three, for signs alone are of no use if employees are indifferent to their purpose. There is collateral work in safety other than human life. So much was learned from curiosity.

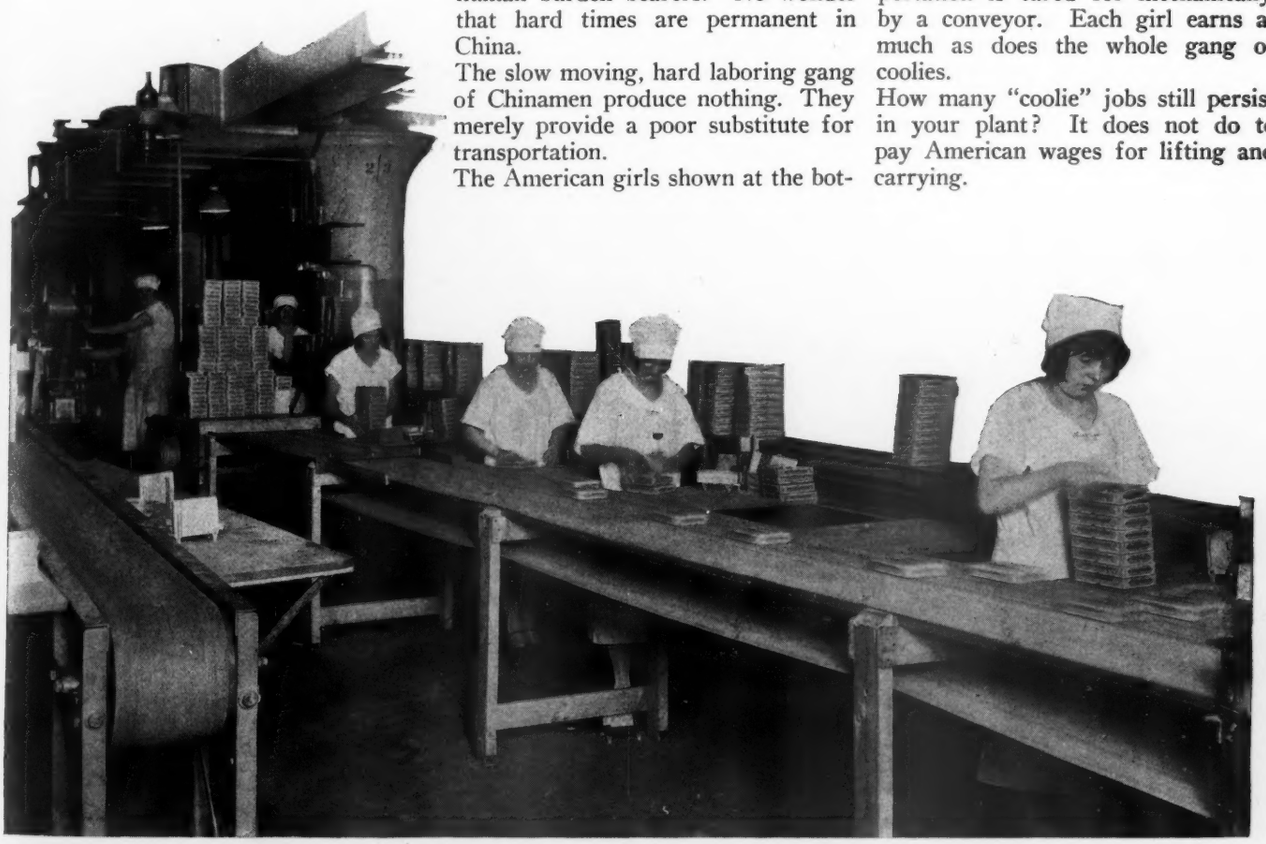
One Reason for America's Prosperity

The coolies of Hong Kong, shown at the top of this page, earn the equivalent of a few cents a day acting as human burden bearers. No wonder that hard times are permanent in China.

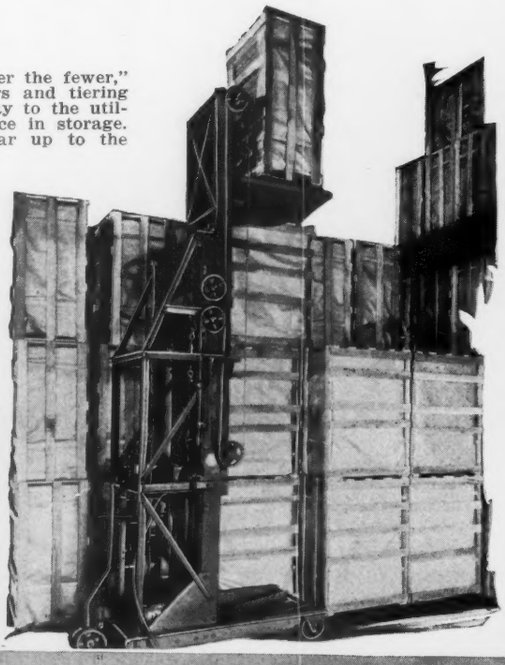
The slow moving, hard laboring gang of Chinamen produce nothing. They merely provide a poor substitute for transportation.

The American girls shown at the bottom of this page are enabled to put one hundred per cent of their energy into production work because transportation is cared for mechanically, by a conveyor. Each girl earns as much as does the whole gang of coolies.

How many "coolie" jobs still persist in your plant? It does not do to pay American wages for lifting and carrying.

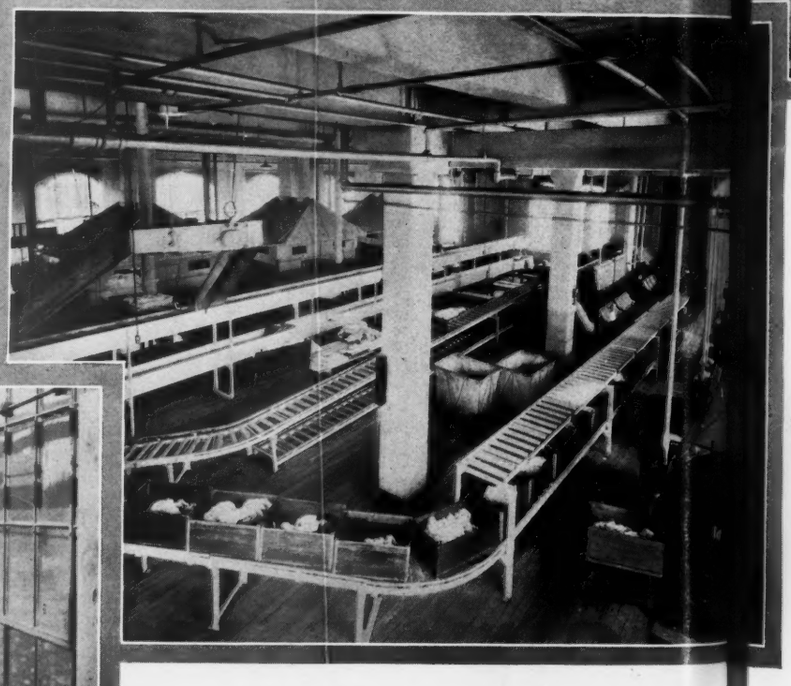


Ideas for Better Handling

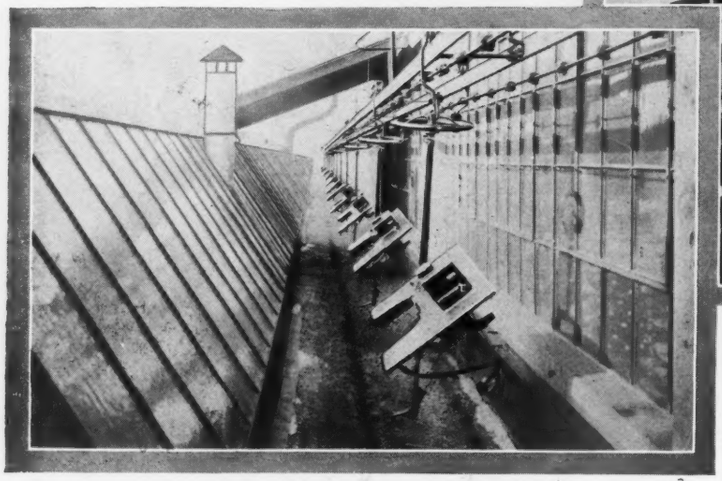


It used to be "the higher the fewer," before portable elevators and tiering machines opened the way to the utilization of overhead space in storage. Now the goods go clear up to the roof.

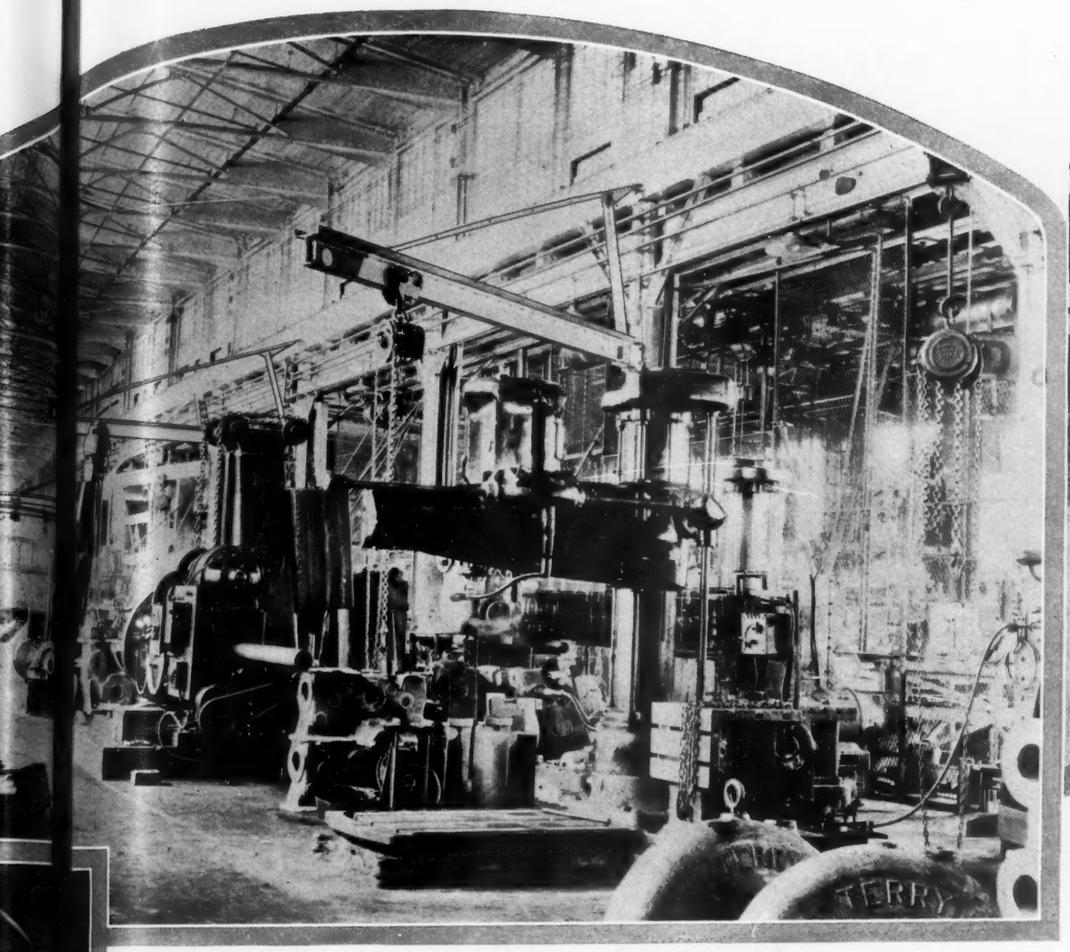
An electric hoist and a hole in the floor constitute an effective working team in this Sherardizing plant. Trucks driving in below with raw materials are quickly unloaded, and the finished product is shipped by reversing the process.



There is a lot of concealed transportation in every industrial plant and it pays to find it and do it mechanically. This modern laundry has done this to its profit.

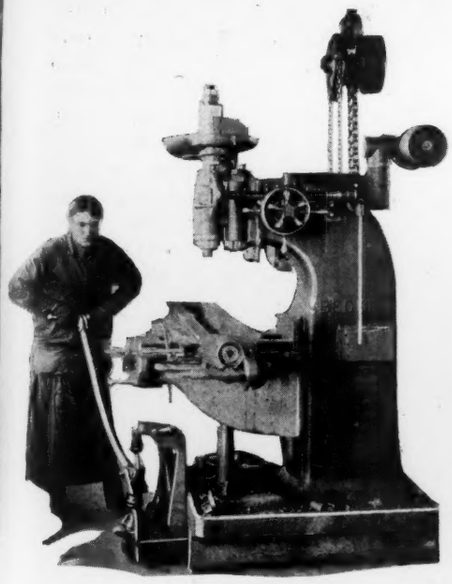


Conveyor lines run between saw tooth and monitor bays on the outside of the roof structure, bringing material from department to department. A good idea when there is no room inside.

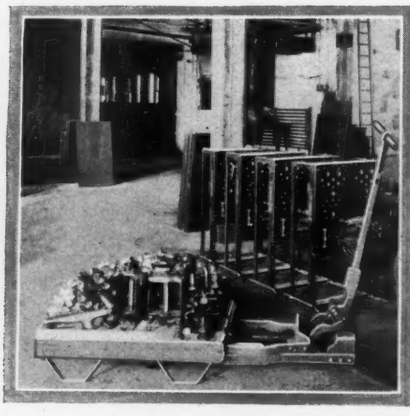


Hand chain hoists mounted on swinging jibs furnish an intermediate service between that of the overhead crane and an electric tractor at the Terry Steam Turbine Plant in Hartford, Conn.

This electric hoist in the plant of the Bryant Heater & Manufacturing Company, of Cleveland, enabled one man to assembled as much as two did formerly. Note the special lifting hooks.



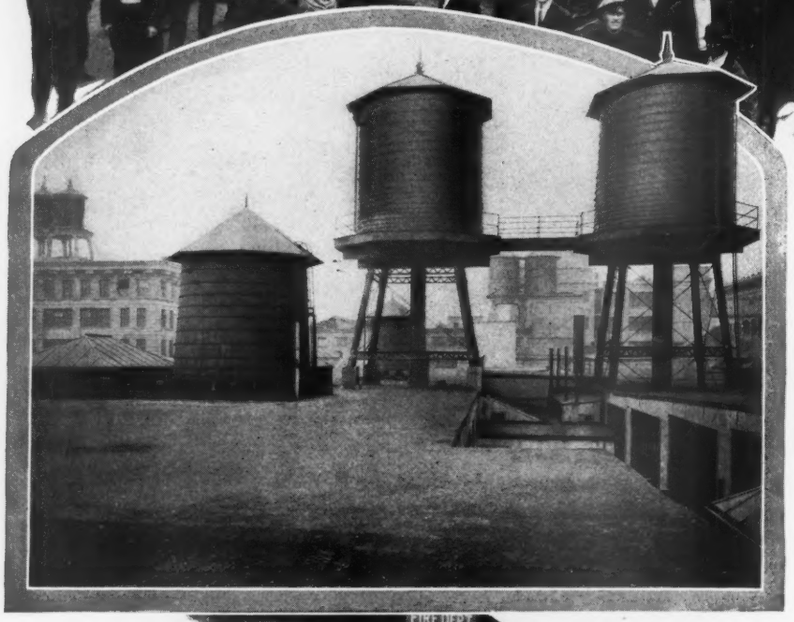
Lift trucks and platforms aid the assembly of heavy and medium weight machinery. The milling machine shown here is assembled and tested on the platform, being transported from place to place in the interior as required, by lift truck.



Platforms for lift trucks are of various types of construction, both standard and special. Here is a light wood and metal platform used in the assembly of small switchboards.

Transportation and storage are combined effectively by the use of hand-lift trucks with removable platforms. The illustration shows chain on the oiling floor at the Chain Belt Company's plant in Milwaukee.

FIRE *and* WATER



Fire and water work in harmony ninety-nine and nine-tenths of the time, keeping these men busy at useful industrial processes. But when fire kicks over the traces, then fire and water must work in opposition, otherwise work is imperiled. The continuance of production in your plant and its profits may some day depend on your water tanks. Make sure that the tank pipes are protected from freezing during the cold season.

Symptoms and Causes of
MOTOR TROUBLES
and How to Remedy Them

IT IS conceded by all who are familiar with the abuses to which electric motors are often subjected in actual service that it is impossible to produce a "foolproof" motor, or one that will operate continuously without any attention.

Regardless of make there will always be a certain percentage of improper installations, unavoidable emergencies, or lack of care that results in motor trouble. For instance, one of the most prolific causes of motor trouble can be traced back to low voltage. The application of power in many localities has been so rapid that central stations have been unable to install heavier transmission lines and equipment fast enough to keep pace with the power demand. The result is that a good many pole transformers and feeder lines are worked beyond their capacity and at certain times of the day when the load is heaviest there is a serious drop in voltage.

This condition has practically the same effect upon the motor as a severe overload and unless the motor has sufficient reserve power or extra capacity to handle this condition without overheating, its continued occurrence will probably cause the windings to burn out. In any event, it is a very objectionable condition that should be remedied as quickly as possible.

Again, a very large percentage of motor trouble can be traced to the conditions under which the motor operates. Inherent electrical or mechanical defects generally appear a short time after the motor is installed, whereas motor trouble due to causes outside the motor is likely to appear at any time.

In such cases considerable difficulty may be experienced in finding the location and cause of the trouble. This is particularly true when the trouble is assumed to be due to faulty operation of the motor itself. Under such circumstances a good deal of time may be wasted in looking for the trouble in the wrong place.

It was with the thought of assisting motor users in general to determine the causes of these troubles more easily and remedy them more quickly, if they occur, that publication of the following trouble charts was undertaken. These charts have been used very successfully for a period of two years and wherever used they have enabled the motor dealer or the electrical department of an industrial plant to render proper service without delay. The charts are so tabulated and condensed that trouble can be located and corrected without loss of time.

These charts were compiled and are copyrighted by The Master Electric Company, manufacturers of small and fractional horsepower motors. A copy of the charts in pamphlet form can be secured by addressing your request to the Master Electric Company, Dayton, Ohio.

TROUBLE SYMPTOMS	PROBABLE CAUSES	TESTS AND THE REMEDY
[A]—MOTOR WILL NOT START ITS LOAD		
Determine by inspection	1. No voltage at the motor terminals. 2. Low line voltage. 3. Fuses blown (See E). 4. Poor contacts or connections. 5. Brushes not set properly. 6. Motor connected to the wrong power circuit (See K). 7. Motor terminals not properly connected to the power circuit. 8. Service lines or transformer, or both, too small. 9. Motor overloaded. 10. Shorted, grounded or open windings (See J, K and L). 11. Worn bearings allowing the rotating part to drop down on the stationary field.	1. See if lights on the same circuit burn or connect test lamp across motor terminals with motor switch closed. 2. Check voltage by applying voltmeter to fuse clips (power side) and also at terminals of the motor. If line voltage is below normal refer to local power company. If abnormal voltage drop in service lines, rewire circuit with larger wire. 3. Check size and condition of fuses. 4. Examine and tighten all loose connections. 5. See that brushes seat well on the commutator and are free to move in their holders. Check the brush setting, making sure that the file marks on brush ring and end cover line up. 6. Check nameplate data with local power company. Nameplate data must correspond with kind of power supplied. 7. Check motor line connections. 8. Have power company check transformer. (Also see No. 2 above.) 9. Remove the load. If motor starts, check entire application for overloads. Check speed. An overload usually causes the speed to drop below nameplate marking. 10. See J, K and L. 11. Inspect the bearings to determine whether tight and properly lubricated.
[B]—MOTOR SEEMS WEAK—RUNS SLOW		
Determine by inspection	1. Low voltage at motor terminals. 2. Motor overloaded. 3. Poor contacts or connections. 4. Motor connected to the wrong power circuits. 5. Motor not properly connected to the power circuit. 6. Motor windings damaged (See J, K and L).	1. See A-2. 2. Remove load. If motor operates at rated speed check bearings for tightness and lubrication. 3. Check all contacts at main switch or auxiliary switches used to operate motor. The shrinkage of fibre or other insulation sometimes used on switches and terminals often causes poor contacts and low voltage at the motor terminals. Clean commutator and make sure that the brushes are free in holders. 4. See A-6. 5. See A-7. 6. See J, K and L.

TROUBLE SYMPTOMS	PROBABLE CAUSES	TESTS AND THE REMEDY
[C]—MOTOR RUNS TOO FAST		
Check speed with speed indicator or tachometer	1. High voltage. 2. Motor connected to wrong circuit. 3. Motor terminals not properly connected to power circuit. 4. Frequency too high (alternating current motors only). 5. Motor windings damaged (See J, K and L).	1. Check voltage on line. High voltage causes excessive speed on d.c. motors only. If impossible to remedy take up with local power company. 2. See A-6. 3. See A-7. 4. Standard frequencies in U. S. for a.c. current motors are 25, 30, 40, 50 and 60 cycles. Determine frequency stamped on motor nameplate and check with power and light company. A frequency above normal will make motor run fast. 5. If d.c. motor test for open shunt field circuit (See J, K and L).
[D]—MOTOR RUNS TOO HOT		
Determine in thermometer reading SYMPTOMS: Distinct odor of burning insulation	1. Motor overloaded during starting and running period. 2. Line voltage too high. 3. Line voltage too low. 4. Belt too tight or coupling or gear out of line. 5. Insufficient lubrication (See I). 6. Faulty commutation (See F). 7. Motor windings damaged (See J, K and L). 8. One fuse blown in two or three phase motor circuit allowing motor to operate on one phase (single phase).	1. Remove load, run motor idle. Give it a general inspection. Apply load gradually if possible and note general characteristics. Inspect for localized heating. 2. See C-1. 3. See A-2. 4. Adjust belt, gear or coupling. Belted motors generally have slotted feet or are mounted on an adjustable base. 5. See I. 6. See F-2. 7. See J, K and L. 8. Shut motor down and attempt to start it after it comes to rest. If it will not start check line fuses and replace defective fuse. If trouble not eliminated check windings for defects (See J, K and L).
[E]—MOTOR FUSES BLOW		
Determine in inspection SYMPTOMS: (a) Motor stops. (b) Motor gets hot (two- or three-phase only). (c) Motor refuses to start.	1. Motor overloaded during starting or running period. 2. Fuse too small. 3. Motor connected to wrong power circuit. 4. Motor terminals not properly connected to power circuit. 5. Damaged motor windings (See J, K and L).	1. See D-1. 2. Check type and size of fuse with fuse information sent with the motor. 3. See A-6. 4. See A-7. 5. See J, K and L.
[F]—FAULTY COMMUTATION		
Determine by (a) Excessive flashing at the brushes. (b) Blackened commutator. (c) Brushes wear rapidly.	1. Protruding mica or rough commutator. 2. Dirt or oil on the commutator. 3. Brushes stuck in brush-holders. 4. Wrong brush position. 5. Brush spring tension too weak. 6. Overloaded motor. 7. Motor windings damaged (See J, K and L).	1. Remove armature and have a thin cut taken off the commutator with sharp lathe tool. While in the lathe polish with No. 00 sandpaper. 2. Clean commutator with a soft rag or with No. 00 sandpaper. Never use emery paper. 3. Release brushes and make sure they ride easily in their holders. 4. See A-5. 5. Replace springs. 6. See A-9. 7. See J, K and L.
[G]—EXCESSIVE BRUSH WEAR		
Determine by inspection Under normal use and if proper care is given the commutator, one set of brushes should function satisfactorily for at least 2,500 running hours. After this period it may be necessary to replace them.	1. Excessive sparking or flashing at the brushes. 2. Wrong quality brush. 3. Rough commutator or high mica between the commutator bars. 4. Overloads.	1. Inspect condition of commutator, also brush spring tension. 2. The Master brushes supplied by the factory are of special composition and carefully selected. Master brushes should be used for all brush replacements to insure proper commutation and satisfactory brush life. 3. If mica segments between commutator bars protrude remove armature and take a thin lathe cut from commutator. Polish with No. 00 sandpaper (never use emery cloth). Surface with a soft rag. Use no oil. 4. See A-9, and D-1.
[H]—MOTOR IS NOISY		
Determine by inspection	1. Worn bearings (See I). 2. Rough commutator or high mica between commutator bars. 3. Unbalanced armature. 4. Brushes fit too loosely in the holder. 5. Armature out of center. 6. Insufficient lubrication. 7. Excessive end play. 8. Air gap not uniform. 9. Loose accessories such as condulet box, guards, etc. 10. Motor mounted on foundation that is not solid or that vibrates when motor is running. Motor not tight on foundation. 11. Bearings not properly assembled. 12. Motor out of alignment (coupling or gear drive only). 13. Damaged windings (See J, K and L).	1. See I. 2. See F-1. 3. Return complete motor to factory for correction or replace with spare armature if available. 4. Replace brushes. 5. Ship motor to factory for correction. 6. Oil thoroughly. For sleeve bearings use a medium-weight, high-grade engine oil. For ball bearings use Master Moto-grease. 7. If end play exceeds .010 in. on ball bearings or 1/32 in. on sleeve bearings tighten adjusting nuts. 8. Replace the bearings. If this does not eliminate difficulty return to factory for correction. 9. See that end covers, guards, condulet box, etc., are tight. 10. Make sure that motor is properly fastened to its foundation and that bolts are tight. The foundation should be rigid to prevent the amplification of vibration noises. 11. Make sure that adjusting nuts are tight. If ball bearings (1) remove dust caps (2) tap races to see if properly seated (3) on classes 6200 and 11200 frames make sure that nut which holds bearing on the sleeve is tight. 12. Loosen motor foot bolts and re-align with driven machine. 13. See J, K and L.

TROUBLE SYMPTOMS	PROBABLE CAUSES	TESTS AND THE REMEDY
[I]—WORN BEARINGS		
Determine by inspection SYMPTOMS: Belt continually running off. Excessive noise. Excessive vibration. Armature or rotor striking field.	1. Insufficient lubrication. 2. Wrong kind of lubrication. 3. Belt too tight. 4. Coupling or gear out of line. 5. Excessive end play.	1 and 2. Replace bearings and lubricate thoroughly. 3. See that belt is just tight enough to prevent slipping during starting and running periods. 4. See H-12. 5. See H-7.
[J]—GROUNDED FIELD OR ARMATURE		
GROUNDED field — Determine by using series lamp or magneto test from motor leads to frame. GROUNDED armature—Determine by using series lamp or magneto test from shaft to commutator. SYMPTOMS: (a) Loss of power. (b) If motor is connected through single-pole switch it may continue to run after switch is turned off. (c) Slow Speed.	1. Copper dust. 2. Oil or dirt on brush-holder parts or where coils enter the slots in the field. 3. Defective insulation. 4. Mechanical damage to insulation in handling. 5. Over-heating sufficient to char the insulation. 6. Damaged winding.	1. Remove all oil, dust or dirt from the motor windings and parts. 2. Look for bare wires near end cover bolts, end of the slots, or where leads are soldered to the winding. 3. Wipe commutator with dry rag. 4. Clean mica between commutator bars especially on the end of the commutator near the steel hub to remove any metallic substance that may have collected there. 5. On Type RA, single-phase motors make sure that short circuiter segments are not touching the commutator when motor is not running. If segments touch the commutator the armature will be grounded. 6. If the windings are making direct contact with the steel or iron frame reinsulate with varnished cloth.
[K]—SHORT CIRCUITED FIELD OR ARMATURE		
Armature short-circuited—Determined in a.c. motor by disconnecting motor from load, lifting all brushes, closing line switch and revolving armature by hand. If strong resistance is offered to rotation, armature is shorted. The shorted coil will center under the stator coil and become excessively hot. If d.c. motor, it will operate at speeds below normal for all loads and the shorted coil will get very hot.	1. Solder between commutator bars where armature leads are connected. 2. Damaged winding.	Regardless of cause proceed as follows: 1. Inspect the soldering of the commutator leads to see that solder does not touch any two commutator bars at the same time. 2. If windings have been damaged and two bare wires are touching each other, reinsulate with varnished cloth or tape. 3. If trouble is not removed by (1) and (2) return the motor direct to the factory for repairs.
[L]—OPEN CIRCUITED FIELD OR ARMATURE		
SYMPTOMS: 1. Burnt mica between two commutator bars nearest open circuit. 2. Excessive flashy sparking around commutator. 3. Refusal to start at certain portions of the armature. 4. Failure to start generally accompanied by a humming sound when motor line switch is thrown on. 5. Reduced speed at any load. 6. D.c. motors with open shunt field show excessive speed at no load.	1. Broken wires. 2. Defective soldering. 3. Damaged winding. 4. Lead wires disconnected. 5. Commutator leads loose.	1. Examine line fuses to make sure they have not blown. This is especially important with two or three-phase motors. 2. See that the motor is properly connected to the line. 3. If a broken wire is apparent make the repair and reinsulate the splice with friction tape. 4. Check point where motor leads connect to the winding. 5. Resolder any loose commutator leads. If open circuit cannot be located return to factory for repair.
[M]—IMPROPER CURRENT SUPPLY		
Determine by checking motor nameplate reading with local power company SYMPTOMS: 1. Motor overheats. 2. Motor is noisy. 3. Motor refuses to start load. 4. Line fuses continually blow.		Replace the motor with one built for operation on the local power circuit.
[N]—WORN BRUSHES		
Determine by inspection SYMPTOMS: 1. Motor refuses to start. 2. Motor not up to normal speed.	1. Overload. 2. Natural wear. 3. Rough commutator.	1. See A-9. 2. Replace with new brushes from the factory. Fit the new brushes to the curvature of the commutator. 3. Polish the commutator with No. 00 sandpaper (never use emery paper) or take small cut off in a lathe.

TROUBLE SYMPTOMS	PROBABLE CAUSES	TESTS AND THE REMEDY
[O]—MOTOR TOO SMALL		
Determine by testing wattage input to motor under load SYMPTOMS: 1. Will not come up to speed when pulling load. 2. Excessive or continuous sparking.		1. Check speed when testing for wattage input. 2. Relieve part of the load or buy a larger motor for the application. 3. The Company will be glad to furnish wattage input data for checking wattage input tests.
[P]—STICKING BRUSHES		
SYMPTOMS: 1. Motor turns but will not always start. Brushes not worn badly. 2. Excessive flashing at the commutator.	1. Presence of dirt or foreign matter in brush holder. 2. Rough spots on brushes. 3. Brush tension spring not applied in the proper place.	Press down on brushes. If motor starts remove brush, clean out holder and sand the sides of the brush down slightly with No. 00 sandpaper. Also sand the commutator.
[Q]—BRUSHES NOT MAKING CONTACT		
Determine by inspection SYMPTOMS: 1. Loss of power. 2. Excessive sparking. 3. Refusal to start.	1. Brush spring tension weak. 2. Brush spring not in proper position. 3. Brushes not properly sanded in to fit curvature of commutator.	1 and 2. Correct brush spring position or replace with new springs. 3. Take a thin strip of No. 00 sandpaper and place under the brush with rough side next to the brush. Hold the two ends close to the commutator bars and sand the brush until it conforms to the commutator curvature.

Details of Tests on Ball Bearing Lineshafts

(Continued from page 64)

two-phase, 875-r.p.m. induction motor driving a 40-ft. lineshaft at 200 r.p.m. This lineshaft was equipped with seven $1\frac{5}{16}$-in. babbitted bearings. The connected load was two presses and a compressor.

Object of Test—To show the direct savings in power, oil and labor resulting from a change to 25, $1\frac{5}{16}$-in. Fafnir double ball bearing hanger boxes all on one line, with the whole installation driven by the one 20-hp. motor.

Method of Conducting Tests—An Esterline graphic wattmeter, used in connection with two Westinghouse 5:1 ratio current transformers, was connected to each motor circuit in turn and a graphic chart obtained of the power input to each motor under load and no-load conditions.

On the ball bearing test the 15-hp. motor was eliminated and the whole load of both motors was easily carried by the 20-hp. motor.

It should be noted that the speed of the shaft on the 15-hp. unit was 200 r.p.m., whereas it was increased to 250 on the drive from the one motor.

Results of Tests:

Load	Babbitt Bearing Test: Div. on Chart	Meter Constant	Kilowatts (20-Hp. Motor)	Ball Bearing Test: Div. on Chart	Meter Constant	Kilowatts (20-Hp. Motor)
Clutches off, belts on loose pulleys.	0.3	× 10 =	3.0	0.07	× 20 =	1.4
Clutches in, no work done	0.4	× 10 =	4.0	0.125	× 20 =	2.5
Running load	0.8	× 10 =	8.0	0.6	× 20 =	12.0
Maximum load	1.1	× 10 =	11.0	0.78	× 20 =	15.6

	15-Hp. Motor	Both Motors Total Kw. Babbitt	20 Hp. Ball Bearing	Saving Kilowatts	Saving Per Cent
Clutches off, belts on loose pulleys	0.12 × 10 = 1.2	4.2	1.4	2.8	65
Clutches in, no work done	0.15 × 10 = 1.5	5.5	2.5	3.0	54
Running load	0.8 × 10 = 8.0	16.0	12.0	4.0	25
Maximum load	1.1 × 10 = 11.0	22.0	15.6	6.4	29

As the average running load is the continuous load, there is a direct power saving of 4 kw. or 5.36 hp.

Saving in Power—A cost of $0.02 per kilowatt-hour and a running time of 55 hr. per week were given.

55 hr. × 50 weeks × 4 kw. × $0.02 kw.-hr. ..... = $220.00
yearly saving in power.

Saving in Oil:

Babbitt bearings — 32 bearings × 150 oilings × 1/40 gal. × $0.40 gal. = $48.00
Ball bearings — 25 bearings × 1 greasing × 1/4 lb. × $0.15 lb. = .94

Yearly saving in oil ..... = $47.06

Saving in Labor:

Babbitt bearings — 32 bearings × 150 oilings × 1/20 hr. × $0.40 = $96.00
Ball bearings — 25 bearings × 1 greasing × 1/12 hr. × $0.40 = .83

Yearly saving in labor ..... = $95.17

Summary:

Yearly saving in power	$220.00
Yearly saving in oil	47.06
Yearly saving in labor	95.17
Total saving	$362.23

Return on the Investment:

Annual saving due to ball bearings	$362.23
Less 5 per cent depreciation charge	21.90
Net annual saving	$340.33
Cost of ball bearings	$438.00

Annual return on the investment = 340.33 ÷ 438 = 77 per cent

Other Considerations:

1. The release of a 15-hp. motor for other work.
2. Bearings are clean—no dripping of grease or oil.
3. Increased production on part of the machines due to increased line-shaft speed.
4. Increased production on all machines due to absence of oil on belts giving less slip.
5. Reduced starting torque, thereby causing less disturbance on the electrical system and less strain on the motor.
6. Much smoother running conditions, thereby eliminating excessive shock loads that show on the first tests taken.

QUESTIONS
Asked and Answered By Readers

HERE IS A PLACE *where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.* Practical Pete

Grounding When Loading Tank Cars

What is the best and safest way to ground the loading pipes and tank cars to prevent static discharges when loading benzol or other highly inflammable liquids? We attach a good ground wire to the end of the loading pipe which enters the dome of the tank car. The track is grounded but not bonded. Should the rails be bonded? Perhaps some reader can give us his method.
Chicago, Ill. J. O. C.

Effect of Reversing D. C. Leads on Alternator

Will some reader help us with the following problem? We have three, three-phase 2,300-volt, 60-cycle alternators that are operated in parallel. Once a year I want to reverse the direct-current leads at the collector rings of these alternators, in order to make the rings wear evenly. One machine would be changed at a time. After reversing the d.c. leads will the alternator be in phase with the other two machines so that I can operate it in parallel with them, or will I have to phase in each time I make this change?
Woodward, Okla. H. J. A.

Preventing Damage to Product by Fine Dust

We are having trouble from fine dust settling on our product (shoes) in the room where these are dressed, cleaned, and packed for shipment. These operations are performed in the packing room, and require from one to two days. We have very delicate leathers and fabrics to deal with and when fine dust settles on them it spoils the appearance and frequently causes damage. The floors and walls are of concrete. The dust, however, is not caused by wearing of the concrete floor; it is the usual fine dust found everywhere in offices, and plants. We have tried several different kinds of oils on the floors, but these did not help us much. We have thought of installing ventilators that would draw the air out of the room, but feared that this would stir up still more dust. We will appreciate any suggestions that readers can give us on how to overcome this trouble.
Lynchburg, Va. R. M. S.

QUESTIONS
Who Can Answer These?

Size of Conductors for Three-Phase Circuit

Can someone tell me what size of copper conductors will be required in a three-phase circuit to transmit 400 amp. a distance of 600 ft. The voltage at the bus in the powerhouse is 2,300 volts, and 2,200 volts are required at the distribution center 600 ft. distant.
Louisville, Neb. D. F. Z.

How Can Motor Shaft Be Demagnetized?

We have a 100-hp., 230-volt, 900-r.p.m. motor equipped with sleeve bearings in which ordinary bicycle chains are used instead of the customary oil rings. The chains have operated satisfactorily until recently when the one in the commutator end bearing failed to turn when the motor was started; nor would it run even when the armature had reached full speed. The pulley-end chain turned as usual. It was then found that the motor shaft was quite strongly magnetized—the commutator end much more so than the pulley end. The motor frame is grounded. The field coils, armature, and brush-holders are not grounded to the frame. Will readers please let me know whether there is any way to demagnetize the shaft? Has any one else had a similar experience and found a remedy?
Norwich, Conn. G. E. G.

How Does Increase in Frequency Affect Core Iron?

I shall appreciate it if readers will give me the answers to the following questions: (1) What is the highest frequency in cycles per second at which commercial core iron can be worked? I am referring to the iron used in transformers and induction motors. (2) What is the highest practical frequency that an induction motor will operate on with reasonable losses? (3) Which loss increases the most rapidly as the frequency is increased?
Detroit, Mich. H. F. W.

Speed of Single-phase Motor Varies Widely

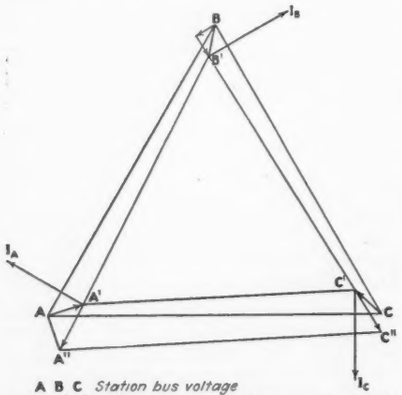
Will some reader please tell me what is wrong with a motor having these nameplate data: G. E. repulsion, single-phase, Type 526-4-1-5-750, Form C, cycles 60, volts 110/220, amp. 4.34-2.17, continuous 55 deg. C. This motor drives a 30-in. exhaust fan. Its maximum speed has been around 400 r.p.m., which would gradually decrease until the motor finally stopped after several hours of operation. The temperature of the motor frame was found to be about 104 deg. F. with a room temperature of 62 deg. F. I found that by pushing the rotor forward against the front bearing it would run freely again. So I put a $\frac{1}{16}$-in. fiber washer on the commutator end of the shaft. I found then that the speed had increased to 2,600 r.p.m. and on successive trials I found speeds of 2,700, 2,800 and 3,100 r.p.m. Why did the motor run so slowly at first, and what caused it to reach such an abnormal speed later?
Brookhaven, Miss. F. H. C.

ANSWERS *Received to Questions Asked*

Voltage Regulation of Three-Phase System

Assume equal spacing between all three lines of a three-phase line having two induction-voltage regulators of 10 per cent rated regulation at the receiving end. If a balanced load is increased indefinitely, will each phase continue to receive the same amount of automatic regulation; that is, hold the same regulated voltage until both regulators reach the maximum boosting position? If not, how much regulation per phase can be given by this connection of regulators with indefinitely increasing balanced load? The connection of regulators referred to is this: In a three-phase line, ABC, regulator No. 1 is connected with its series coil in line A, and the potential terminals connected across phase AB; so that if a test were made with the regulator rotor in a boosting position and line C entirely removed from source to the load during this test, phase AB voltage would be boosted. No. 2 regulator is connected with its series coil in line C, and the potential terminals connected across phase BC; so that a test made with the regulator rotor in a boosting position and line A entirely removed from the source to load during the test would show the voltage of phase BC to be boosted. We shall appreciate readers giving vector diagrams to illustrate the points in question. Also, is the two voltage-regulator system of regulation in three-phase circuits considered superior to three single-phase regulators electrically as well as economically?
Beardstown, Ill. F. H. L.

In reply to J. W. D. C., a vector diagram showing the conditions which obtain in such a circuit such as he describes is given in the accompanying sketch. In this diagram, the resistance and reactance components of the drop from the bus to the center of distribution are shown only in the B phase, although the resultant drops are shown in the other two phases. It will be noted that *A'B'C'* is an equilateral triangle, although displaced in phase relation from the bus voltage triangle *ABC*. It is, therefore, evident that regulators excited from *A'B'C'* will have the same excitation on each regulator and the same induced voltage. The result will be that equal regulation is obtained on all three phases as shown by the voltage triangle *A"B'C"*.



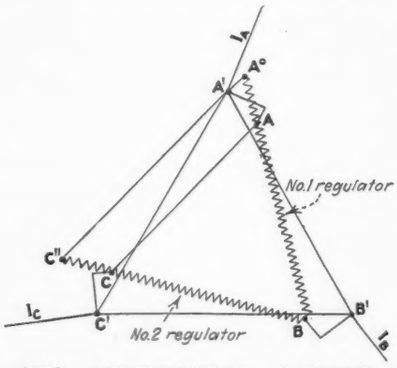
CONDITIONS EXISTING WITH TWO SINGLE-PHASE VOLTAGE REGULATORS ON THREE-PHASE CIRCUIT

If the load is balanced, as mentioned in this case, there would be no advantage from any standpoint in using three single-phase regulators rather than two single-phase regulators. Furthermore, a three-phase regulator will give as good results as the two single-phase regulators, and in general will cost approximately the same as the two single-phase units. Also, it will occupy less space and require less maintenance, as only one set of control apparatus will be required.

F. J. CHAMPLIN.

Designing Engineer,
Feeder Regulator Dept.,
General Electric Co., Pittsfield, Mass.

The sketch shows the connections described in J.W.D.C.'s question, in the form of a vector diagram. Here. *A'B'C'* represents the voltage at the supply end of the feeder; it is assumed that it is a balanced, three-phase



TWO SINGLE-PHASE VOLTAGE REGULATORS ON A THREE-PHASE CIRCUIT

voltage. The voltage at the receiving end will be balanced, but of a lower value and of slightly different phase from the voltage at the supply end, the actual value depending upon the impedance of the line. The receiving end voltage is represented by *ABC*. Since the voltage induced in the secondary of a single-phase induction regulator is in phase with the primary voltage, the secondary voltage will add to the line voltage, as shown by windings *CC"* and *AA"*. Phase voltages *A"B* and *BC"* will be equal because the potential transformers for automatic accessories are connected across these two phases. From the symmetry of the figure, it will be seen that voltage *C"A"* will be equal to *A"B* or *BC"*, thus producing a balanced three-phase voltage at the load.

Two single-phase regulators on the three-phase, three-wire system should not be directly compared with three single-phase regulators on a three-phase, three-wire system, as they have different applications. In general, the applications of voltage regulation on three-phase, three-wire system are as follows: (1) For balanced loads where phase displacement is not objectionable, three-phase regulators are most satisfactory. (2) For balanced or slightly unbalanced loads where the regulation of the third phase is unimportant, and where phase shift is objectionable, two single-phase regulators are used. (3) For unbalanced loads and where all phases must have the correct voltage, three single-phase regulators are used.

E. R. WOLFERT.

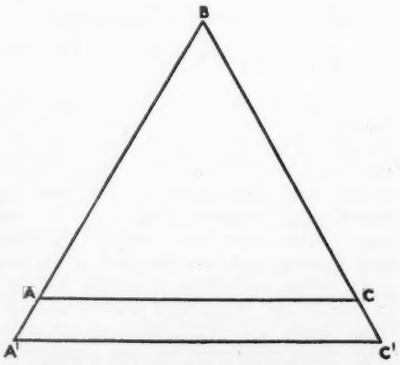
Motor Engineer,
Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.

Referring to J.W.D.C.'s question, the use of two single-phase induction voltage regulators for controlling the voltage of a three-phase bus or feeder is quite common practice, and the results obtained are fully as good as those obtained with one three-phase regulator unit. It is necessary to use three regulators only when the unbalancing is severe; then a third single-phase unit is easily added. A three-phase unit would not handle a badly unbalanced load as well, and might have to be eventually replaced by three single-phase units. From this last standpoint alone the flexibility of single-phase units is a great advantage. Naturally, three single-phase units will take up somewhat greater floor space than one three-phase unit.

The illustration shows the vector conditions when two regulators are used. Here *ABC* represents the normal system, *AA'* represents the boost on phase *AB* and *CC'* the boost on phase *BC*. It follows, then, that the unboosted phase *AC* becomes *A'C'* which under balanced conditions is the same as *A'B* or *BC'*. Although it cannot be said that two single-phase regulators are superior to three, actual practice indicates that in general use they give excellent results, for even though the third phase is actually not being boosted, it is always affected by the boost on the other two.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corporation,
New York, N. Y.



VECTOR CONDITIONS WITH TWO VOLTAGE REGULATORS ON THREE-PHASE SYSTEMS

ANSWERS *Received to Questions Asked*

Layout of Belt Drive for Waterwheel-Driven Generator

We are installing a 400-r.p.m. waterwheel to drive a 1,200-r.p.m., 100-hp. generator. The plans call for a drive pulley 60 in. in diameter with its center less than 10 ft. from the center of the 20-in. generator pulley. Both pulleys are 10 in. wide. We now have the pulley for the generator, but not for the waterwheel. Will readers please tell me (1) the minimum distance between pulley centers that could be used for this drive? (2) What width and thickness of belt should be used? (3) What kind or type of belt tightener should be used? (4) If the belt speed will be too high with the pulleys mentioned above, what sizes of pulleys can be used to drive the generator at the proper speed?
Allende, Coah., Mexico. **L. N. S.**

ANSWERING L. N. S.'s question, I would recommend a medium weight double waterproof oak or chemically tanned belt, 10 in. wide, but as the speed of the belt would be rather high with a 60-in. drive, and a 20-in. receiving pulley, it would probably be best in this case to use a 48-in. drive and a 16-in. receiving pulley, the receiving pulley to be preferably of the paper type and both pulleys should be crowned. With this arrangement a belt speed of 5,027 ft. per minute will be obtained instead of 6,283 ft. per minute.

If space will permit, I would recommend that centers of from 10 to 16 ft. be employed, if possible, and thus eliminate the necessity of using a belt tightener. If, however, it is found that the belt centers are too great, it will be necessary to use some type of belt tightener, several satisfactory ones being sold on the market.

In a job of this kind it is absolutely necessary to have the pulleys accurately squared and lined up. Also, for such high speeds it is advisable to use an endless belt. F. D. HEWLETT.
Allison, Ala.

AS THE proposed installation as described by L. N. S. necessitates a very high speed for a belt drive, special attention should be given to the practicability of using this drive.

The belt speed in this case is 60x3.14 x400 ÷ 12 = 6,300 ft. per minute and the pull on the belt per inch of width is (33,000 x 100) ÷ (6,300 x 10) = 52.3 lb.

As space for the drive is limited, it will probably be necessary to use a belt idler for the purpose of carrying the required horsepower on this job.

For this type of drive the center distance of the pulley need not exceed the diameter of the larger pulley, if a ratio not much larger than 3 to 1 is employed.

I would recommend that the 60-in. drive pulley be replaced by a 48-in. one in which case a belt speed of 5,030 f.p.m. will be obtained and there will be an effective tension of 45 lb. on the belt. In this case a 15-in. belt and a 16-in. diameter generator pulley will be used.

As it happens, we have a beater drive which requires 75 hp., the power being supplied by a 900-r.p.m. motor fitted with a 15-in. diameter pulley having a 15-in. face that in turn drives a 15-in. heavy double-ply endless leather belt which is kept taut on the pulley by a Lenix idler. As this installation is just three-quarter the horsepower and three-quarter the speed of L. N. S.'s installation, I believe that my recommendation should prove helpful.

We are installing two new beaters, and they are to be driven by Texrope drives and as the installations that I have seen worked very nicely, it might pay L. N. S. to investigate this type of drive. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

Fastening Rotor Bars to End Rings

The heating of the rotor in one of our squirrel-cage induction motors during the starting period affects the soldered connections between the bars and the rings enough to make it necessary to resolder these connections about every 6 mo. Will readers tell me how to solder or secure the bars permanently to the rings so as to eliminate further trouble with them? If silver solder, or some other kind, is employed, I should like to know what flux to use, together with any suggestions you can give me on how to do the job.
St. Marys, Ont., Can. **W. E.**

REFERRING to the answer by W. E., fastening rotor bars to end rings by means of welding has proved successful in many instances, when silver solder is used, for I have known rotors to operate for ten years successfully after being soldered.

A 70 per cent grade of silver solder, as used by us is purchased from one dealer, although a similar grade is supplied by one motor manufacturer that I know of.

Borax is used generally as a flux, and an oxy-acetylene torch is used for soldering the rotor bars to the end rings. When soldering, care must be exercised in order to prevent the melting of copper on very small bars and rings. In old types of motors, the end rings consist of multiple copper plates which are rather thin. It is almost impossible to make a good job of silver soldering with this construction, but this difficulty can be overcome to a great extent by using a piece of ¼ in. x 1 in. stock (or any width necessary) rolled into a circle and fitted under the ends of the bars. The bars are riveted to the improvised ring and the joint between the bars and the ring is soldered as was the lap joint in the ring. In certain cases where a high resistance type of bar and end plate are used, a brass end ring is cast and machined to size, the size being determined by measuring the end rings of other motors of similar characteristics.

Special attention should be given one point; that is, the joint to be soldered must be clean in order to secure a good job, for if the connection between a bar and the ring is oxidized, the rivets should be cut out and the ring removed and thoroughly sanded, likewise the sides, top and bottom of the bar.

After the ring is replaced and riveted, the job may be soldered. If the rotor has not been overheated too often and the bars are not oxidized, the bars as well as the entire rotor may be cleaned by dipping the entire rotor in a tank of Oakite Platers Cleaner solution, about one and one-half ounces to one gallon of water, which is maintained near the boiling point.

After silver soldering the rotor, it should be carefully balanced to secure smooth operation and excessive wear on the bearings. The completed rotor may be painted if care is taken to keep paint off the portion in the air gap and out of ventilating air ducts.

Some old types of motors have the bars insulated in the rotor slots. The insulation is not necessary for the proper operation of the motor, but it must be replaced if it is roasted out in order to prevent noise and excessive vibration in the rotor. J. ELMER HOUSLEY.
Alcoa, Tenn.

THE trouble that W. E. has experienced is common. The difficulty is generally caused by the combined effect of heat and centrifugal force. To overcome much of this trouble many manufacturers have adopted one of two methods. Either riveting or welding.

If the joint between the rotor bar and the ring is not a good one, the heat generated by the high resistance of the joint may be enough to melt the solder when the motor is operated. Consequently, it is a good plan to always make a good joint before soldering, making the contact surface a little greater than theoretically necessary.

The best solder to use is one with a high melting point, as the heating at the joint is bound to be considerable when the motor is working at full load. I have had good results using a 55 per cent lead, 45 per cent tin solder and for a flux use only resin dissolved in methylated spirits. In making up the flux use only about 4 pints of methylated spirits to 7 lb. of resin. When soldering, keep a small quantity of solder melted in a small metal pot, using two ladles, one to pour the solder over the joint, and the other to catch any solder as it falls off.

Depending of course on the space available between the joints, this method can be more or less conveniently carried out, care being taken to see that the solder does not fall between the windings. If necessary, put something under the joint to prevent this.

W. E. WARNER.
Brentford, England.

ELECTRICAL SERVICE

Around the Works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Operating Trouble Eliminated by Starting Motor Slowly

DURING the past year we were called upon to solve a problem for one of our power customers who is operating a creamery. One of the machines in his plant is a milk separator and must be started gradually. At the time we were called in, this separator was being started by gradually moving a belt, by means of a handwheel, from the loose to the drive pulley. As the slippage of the belt on the drive pulley was excessive, frequent belt renewals were necessary.

This unsatisfactory starting method was replaced by gradually starting the motor while the belt was on the drive pulley and connected to the load. In place of using the cumbersome handwheel arrangement to move the belt from the loose to the drive pulley, a semi-automatic resistance starter was installed to control the starting of the squirrel-cage motor.

The experience we gained on this job brought to our attention the advantages of a resistance starter over other methods of starting squirrel-cage motors. Although we have for years been using ordinary compensators for starting such motors, we have recently found that by the use of a separate resistance control for starting, line disturbances and equipment troubles could be greatly reduced.

Vice-President, J. F. GIRTEN.
Union Public Service Co.,
St. Paul, Minn.

Adapting 220-Volt Compensator To 440 Volts

A COMPENSATOR-TYPE starter for a 440-volt induction motor recently failed beyond repair, and a replacement was not available without considerable delay. An old 220-volt compensator was on hand, however, and as a long shut-down could not be considered, it was necessary to adapt it to the 440-volt service.

The auto-transformer would operate satisfactorily on 440 volts as the voltage ratio was still the same. The overload trip could also be adjusted to suit the motor, because its operation depended only on the current flowing. The low-voltage coil, however, was connected across the line in the running position and would not stand the higher voltage. A test was made with a resistance in series with this coil, but it was found that the contactor would not then pull in when starting, although the resistance was as low as possible to keep the coil from overheating in the running position.

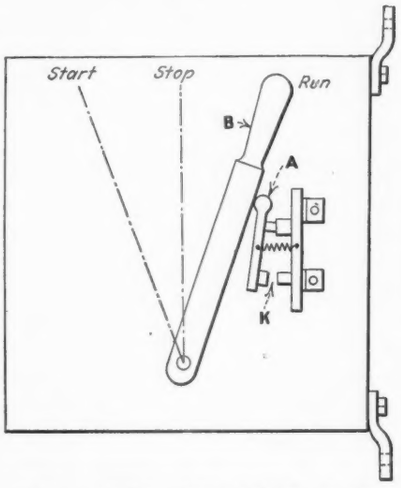


FIG. 1—THE INTERLOCK *K* IS OPEN ONLY WHEN THE HANDLE IS IN THE RUNNING POSITION

Normally, without the resistance, a comparatively large current flowed in the coil to pull in the contactor, but when the armature closed the magnetic circuit, the current was reduced. The resistance inserted would not allow this high current to flow at first, hence the contactor did not close.

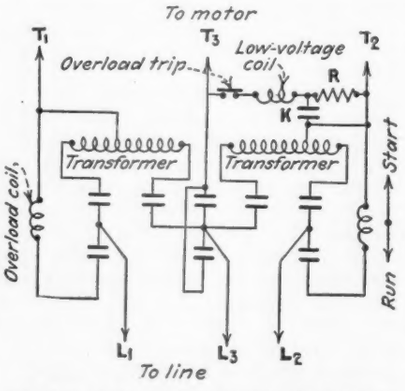


FIG. 2—WITH THE RESISTANCES *R* AND *K* ADDED TO THIS STARTER, *K* SHUNTS OUT THE RESISTANCE DURING THE STARTING PERIOD.

To remedy this defect, a normally closed contact *K* was mounted on the outside of the box, as shown in Fig. 1, so the starting lever opened it when in the running position. Connections were made as in Fig. 2, *R* being 750 ohms, and *K* the contact mentioned. Contact *K* is a type often used on control boards for electrical interlocks, being operated by cams on the armatures of contactors. A spring normally holds it closed, but the starting lever *B* strikes the arm *A* and opens the contact when in the running position. Resistance *R* is thus shunted out while the compensator is in the starting position, and the contactor pulls in. This time is so short that the low-voltage coil is not damaged, and the resistance is thrown in for the running position.

Two Ward-Leonard resistance tubes of 1,500 ohms each were mounted on the wall near the compensator and connected in parallel with the resistance *R*. The unit was placed in service in this manner and gave satisfactory results.

Chicago, Ill. K. M. WHITE.

How to Locate Faulty Fuses on Three-Phase Motors

WHILE servicing three-phase motors in our locality, we had considerable difficulty in locating blown fuses on three-phase motors. The fuses on any of these motors are alive only when the switch or compensator is in the running position. Consequently it is not convenient to test the fuses with a test light when the motor is not running. If the fuses are tested by a lamp when the motor is running single phase, it is difficult to locate a blown fuse, due to the fact that the voltage is kept nearly normal on the motor side of the blown fuse by the generator action of the motor.

Under these conditions we find it best to shunt each fuse momentarily with a short piece of insulated wire, instead of testing from the end of one fuse to the end of another. When a blown fuse is shunted by means of a wire, a spark will indicate that the fuse is blown and the absence of a spark will indicate that the fuse is a good one.

R. B. TURNER.
Manager
Johnson-Turner Electric Repair & Engineering Co.,
Walkerville, Ont., Can.

Mechanical Maintenance of
POWER DRIVES

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Obtaining Half-Speed Drive for Special Work

ALTHOUGH many machines and their drives are designed for a single speed, it is often desirable to obtain a special speed, either higher or lower, for certain kinds of work. Such was the problem in one plant where a machine was used about three weeks out of the month on one line of production and the remaining week on a different product, which was processed at approximately half the standard machine speed. This machine was connected by a 3½-in. belt and a 2-hp. constant-speed motor mounted on the ceiling.

A two-speed drive was obtained by means of an extended pulley and a countershaft mounted a few feet away from the motor, as shown in the accompanying illustration. The original motor pulley was 3 in. in diameter with a 4-in. face. A special extended pulley was made from a piece of 3-in. steel shafting about 8 in. long, which was bored out at one end to fit the motor shaft and the outside of which was turned to make two 3-in. pulleys attached solidly, end to end, with a slight crown turned on each. To decrease the weight on the overhanging end the outer end of the pulley was bored out for about 4 in. to give a ⅜-in. shell on the extension. The pulley was fastened to the motor shaft with a setscrew and key. A countershaft was then erected on the ceiling about 30 in. from, and parallel to, the motor shaft. This countershaft carried a step-cone pulley; one step was 3 in. in diameter, the same as the motor pulley, and the other twice this diameter.

For ordinary operation the belt is extended from the pulley next to the motor down to the machine. When half speed is wanted, the motor belt is placed on the large pulley of the countershaft, which is supported by adjustable drop hangers so that the countershaft can be removed and replaced easily.

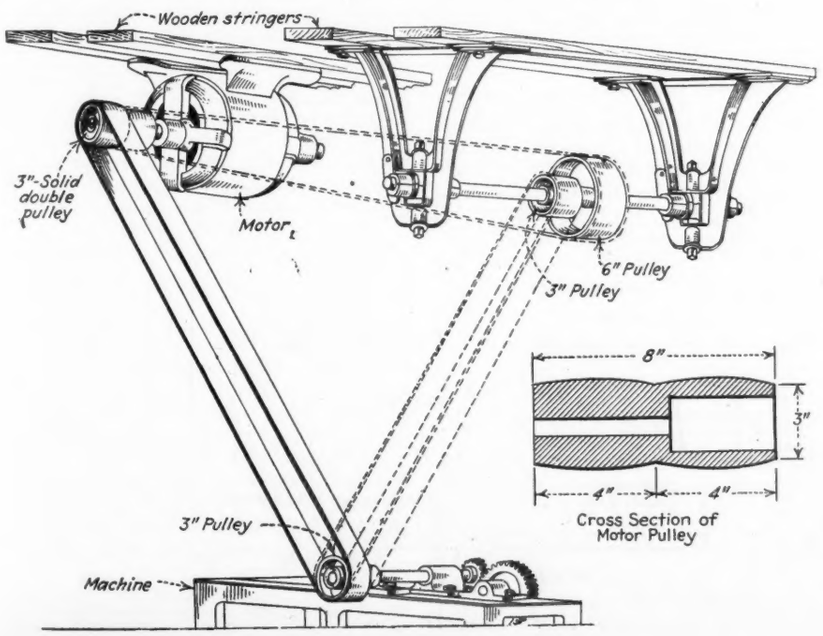
The countershaft is so placed that the smaller pulley is in direct line with the pulley on the machine and at such a distance that the same belt can be used to drive from the countershaft to the machine as is used from the motor down to the machine.

The short belt used to drive the countershaft is kept by the machine operator who is held responsible for it. The change-over requires only about 15 or 20 min. A similar plan can be used if it is desired to increase the machine speed, or obtain any other ratio of change, by an appropriate arrangement of driving and driven pulleys on this countershaft.

South Milwaukee, Wis. E. D. F.

A SPECIAL COUNTERSHAFT ARRANGEMENT FOR OBTAINING A HALF-SPEED DRIVE.

During ordinary operation the motor is belted directly to the machine. For half-speed operation a special belt is placed from the extended end of the motor pulley to the countershaft. The original driving belt is taken from the pulley and attached to the small cone pulley on the countershaft.



Solving the Dust Problem on a High-Speed Pulverizer Drive

BEARINGS which operate in exceedingly dusty locations, such as on many of the drives in cement mills, usually give considerable trouble from the dust working into the oil or grease lubricant and causing scoring. This soon results in a hot bearing and often in a complete failure. High-speed operation or heavy bearing pressures, when combined with dust, increase the difficulty of lubrication and may cause a good deal of trouble.

A good example of such a problem and its solution is in connection with the bearings on a No. 3 Williams hammer mill at the Kosmos Portland Cement Company, Kosmosdale, Ky. This mill is driven at 750 r.p.m. by a direct-connected 100-hp. motor and operates practically 90 per cent of the time during the 24 hours.

The oil and bearing-upkeep costs were almost prohibitive with the ring-oiled bearings originally installed. Practically the only method of keeping the dust out was to supply sufficient oil to continuously flush the bearings and wash out any solid materials. This, of course, caused a high oil consumption and the excess oil ran down over the machine and caked with the dust which settled into it.

This mill handles about 60 to 75 tons of hot limestone per hour and the frequent interruptions to renew the bearings seriously interfered with production. The only apparent solution was to use a bearing which would keep the dust out. Therefore, 4 7/16-in. Fafnir bearings of the double pillow-block type with special extra dust seals were installed on this drive in 1922 and have given no trouble since. The bearings now are lubricated once a week with a lubricant consumption of about 25 lb. of cup grease per year. No additional upkeep expense has been necessary.

Comments on "Application of Gears and Speed Reducers on Motor Drives"

THE comments which appeared on pages 388 and 389 of the August, 1927, issue of INDUSTRIAL ENGINEERING, on an article by Gordon Fox carrying the above title, contained an error in a formula. Also, later data have been obtained for the tabular material published in August.

In the third full paragraph on page 389 the equation $[150 \div (200 + V)] + 0.25$ appears as $[150 \div (600 + V)] + 0.25$ which makes a decided difference in the results should any one happen to use it. Further on in that paragraph, the expression "3-in. diametric pitch" has been used instead of "3 diametral pitch."

In the last paragraph of the first column on page 389 the equation $[125 \div (150 + V)] + 0.25$ should be $[150 \div (200 + V)] + 0.25$, which is the newly adopted standard for non-metallic material.

New data have been obtained for the table showing the respective tooth-strength value for cast-iron and non-metallic gears of a specific type under different rates of speeds. This table should appear as follows:

Speed F.P.M.	Tooth Strength in Horse Power	
	Cast Iron	Non-Metallic
500	11.9	7.9
1,000	15.5	13.0
1,500	17.5	17.9
2,000	18.6	22.6
3,000	19.8	32.1
4,000	20.5	41.4

In view of the revised table, the statement in the paragraph preceding the table (at top of middle column on page 389) should be changed by the substitution of "about 1,500 r.p.m." for "slightly over 2,000 r.p.m. or at approximately 1,600 f.p.m. pitch-line velocity."

T. C. ROANTREE.
Non-Metallic Gear Application Engineer,
Westinghouse Electric and Manufacturing Company,
East Pittsburgh, Pa.

Careful Attention Overcomes Bad Operating Conditions

INSECURE foundations coupled with considerable vibration have not interfered noticeably with the successful operation of the chain drive shown in the accompanying illustration. This drive has been installed for about 3½ years at the plant of the Municipal Street Paving Department, Springfield, Mass., and drives asphalt mixers and a system of conveyors. The installation is mounted on a scaffold which, obviously, cannot be as substantial as a concrete foundation and necessarily permits considerable vibration.

The material handled by the mixer is extremely viscous. This results in a very heavy load and wide fluctuations in load, which, in combination with the vibration, results in severe operating conditions. The heavy steel casing, the top half of which is removed in the illustration, protects the chain from the cloud of dust surrounding the drive at all times. This satisfactory operation has resulted from daily attention to lubrication and the careful inspection of the casing to see that the joint between the two halves is kept sealed to exclude dust.

CHAIN DRIVE SUBJECT TO VIBRATION, FLUCTUATING LOADS AND DUSTY SURROUNDINGS.
This Whitney chain drives an asphalt mixer and a system of conveyors, a type of work which subjects it to dust and extremely severe operating conditions.

The main shaft of the installation is driven at 100 r.p.m. by a 75-hp., 580-r.p.m. motor with an outboard bearing. The reduction is obtained through a 10-in. Whitney silent chain of 1-in. pitch operating over gears of 23 and 133 teeth on approximately 5-ft. centers.

D. I. WHEELER.
The Whitney Manufacturing Co.,
Hartford, Conn.

Driving Double-Purpose Blower at Two Speeds

TWO tumbling barrels and a blower in the foundry of a New York manufacturer of supplies and machinery for the woodworking industry are driven in an interesting way, as may be seen by referring to the accompanying drawing. All three units are located so that they can be driven from a secondary shaft which is belted to a lineshaft that extends through the wall from the machine shop. The tumbling barrels are driven from tight-and-loose pulleys on the secondary shaft; these are not included in the sketch.

The blower supplies air for a 5-ton cupola and is also used as an exhauster for the tumbling barrels by driving it at a slower speed than for the cupola. Ordinarily, a foundry has a smaller blower which is used to exhaust from the tumblers. Thus the arrangement used here combines the work which ordinarily requires two blowers. Inasmuch as the cupola is used after 2:00 p.m. and the tumblers are emptied by noon, there is no conflict of demands.

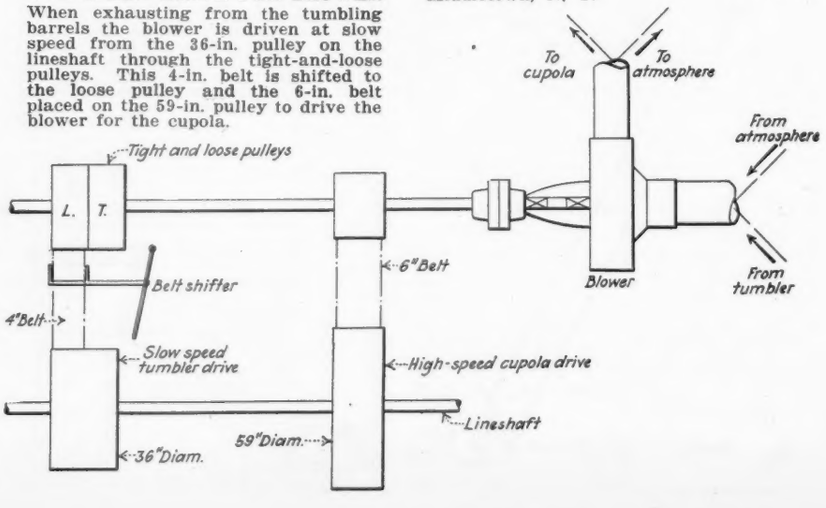
The arrangement of the two-speed belt drive is shown by the drawing, which is a plan view of the layout with the shaft distances shortened for compactness. The lineshaft carries two large, wooden driving pulleys. The secondary driven shaft is direct-connected to the blower by a flexible coupling; thus the blower runs at shaft speed whenever the driven shaft is operating.

When driving the blower as an exhauster, a 4-in. belt is used from the 36-in. pulley on the lineshaft to the tight-and-loose set of pulleys shown. These pulleys enable the helper to cut off the blower when the tumblers or cupola are not in use. When the tumblers are in use the 4-in. belt is shifted onto the tight pulley and the 6-in. or high-speed drive belt is slipped off its pulleys and caught on a belt perch. In the afternoon when the blast is needed for the cupola the 4-in. or low-speed drive belt is shifted to the loose pulley and the 6-in. belt is replaced on its pulleys. The belts are again changed back the next morning for the tumbler and slow-speed exhauster drive.

Branches in both inlet and outlet pipes to and from the fan, with a shut-off gate in each, direct the flow of air as desired. For exhausting, the gate from the tumblers and the outlet gate to the atmosphere are opened. For the blast, these gates are closed and the other two opened. A double-purpose blower is thus secured by a simple shifting of the drive.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Manufacturing Company,
Middletown, N. Y.

TWO-SPEED DRIVE FOR BLOWER
When exhausting from the tumbling barrels the blower is driven at slow speed from the 36-in. pulley on the lineshaft through the tight-and-loose pulleys. This 4-in. belt is shifted to the loose pulley and the 6-in. belt placed on the 59-in. pulley to drive the blower for the cupola.



In the REPAIR SHOP

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Causes and Remedy of Induction Motor Noises

VARIOUS noises due to the operation of induction motors, can be divided into three classes according to the cause, namely: magnetic, current, and windage.

The magnetic hum varies all over the sound scale from a faint hum to a high-pitch and noise or squeal. This hum is due in most cases to loose iron or to the vibration of the iron in the core that is being acted upon by pulsating fields of high frequency. This pulsating current depends on the frequency and flux density in the core, as well as on the shape, material, and dimensions of the magnetic circuit.

Magnetic noises can in most cases be distinguished by the fact that they remain practically constant at all loads. Such noises depend primarily on the frequency, a 60-cycle motor being more noisy than a 25-cycle machine.

The coil pitch affects the field form, which in turn also affects the magnetic noise. The ratio between the number of stator and rotor slots also has an important effect on the noise. With motors using large open slots, a well-designed metal or magnetic wedge will help to reduce the noise.

Skewing the rotor slots also helps to reduce the noise, the amount of skewing depending on the rotor and stator slot pitches. On the average the amount of skew is one rotor slot pitch.

Current noise sounds like a low growl or heavy rumble and in most cases is accompanied by vibration of the complete motor. This noise is due to unsymmetrical electrical or mechanical parts or circuits, and varies with the load, being loudest at starting and at full loads. It can be reduced by making any alterations found to be necessary upon testing for an unequal air gap and other mechanical variations and also by checking the coil grouping and connections for perfect balance.

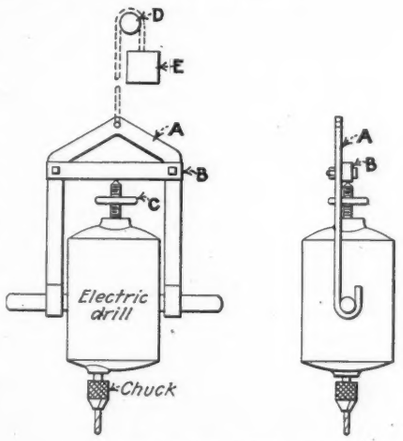
Windage noises, which are caused by parts projecting out from the rotor and causing a whistling sound, may be due to slot cells being left open at the ends, or to deep rotor bars. Windage noise can be distinguished from current and magnetic noises by bringing the motor up to full speed and then suddenly throwing off the current. If the noise stops suddenly it is due to current or magnetic causes, as windage noises will continue as long as the rotor is moving, becoming lower in pitch and intensity as the rotor slows down.

A. C. ROE.

Renewal Parts Engineering
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

Convenient Support For Electric Drill

WHENEVER it is necessary to bore a great many holes with a portable drill, some means of supporting the drill in a flexible manner will frequently lessen the strain on the workman and also make it easy to bore holes vertically. One instance with which I am familiar required the boring of several thousand holes in lumber.



FLEXIBLE SUPPORT FOR PORTABLE DRILL

To support the drill used, a piece of iron ½x1½ in. was shaped by the blacksmith as shown at *A*, in the accompanying illustration. The cross piece *B* was used to hold the electric drill firmly in place by turning up the feed screw *C*. A rope, pulled up over a pulley *D*, and a counterweight *E* nearly lessened the strain considerably.

Changing 120-Volt Series Motor to 220-Volt Shunt Type

IN AN industrial plant the installation of a new machine was being held up for the lack of a 10-hp., 220-volt, 900-r.p.m., d.c. motor that could not be obtained from the factory except on a long time delivery. This meant a serious delay; so after canvassing the various repair shops a 15-hp., 120-volt, 900-r.p.m., four-pole series motor was found, which might be used with the new machine, if certain changes were made. The armature had 39 slots and 117 commutator bars and was simplex-wave connected, therefore having but two circuits. The armature coils were constructed of one turn of copper ribbon, 0.051 in. x 0.375 in., the area of which is 19,125 sq.mil, or 24,338 circ.mil.

As two circuits represent the minimum number any armature may have, it was seen that it would have to be rewound instead of being reconnected. The original coils had but one turn; so for operation on twice the former voltage the number of coils would have to be twice as great; that is, each coil must have two turns, assuming, of course, that the new connection would be simplex wave. The area of the wire used in winding the new coils should be one-half the original area or 12,169 circ.mil, the nearest size to this being No. 9 wire with an area of 12,996 circ. mil. The trial coils that were made of No. 9 wire fitted into the slots without any difficulty.

The series field was wound with 96 lb. of two No. 6 wires in parallel, whose resistance of 0.1 ohms was determined by a slide wire bridge. According to the nameplate, the full-load current at 120 volts was 112 amp. The watts lost in the fields I^2R, at full load was $112 \times 112 \times 0.1 = 1{,}254$ watts. This is about 11.2 per cent of the current used. Practically, a series motor is seldom fully loaded and this job required only 10 hp. It was considered that the average field losses would be considerably less; so 300 watts were assumed.

The current taken by the shunt field according to Ohm's law would be $300 \div 240 = 1.25$ amp. In order to have the same number of ampere-turns at the same full-load speed approximately the same weight or 96 lb. of wire having a resistance of $240 \div 1.25 = 192$ ohms must be used. The nearest wire corresponding to a resistance of 192 ohms for 96 lb., was found to be No. 19 wire, which has approximately 185.2 ohms for 96 lb.

The area of No. 19 wire is 1,288 circ. mil; therefore, it would be required to carry $240 \div 185.2$ or approximately 1 amp. The circular mils per ampere would then be $1{,}288 \div 1.3 = 990$, which is a trifle low, the usual values for shunt field coils being between 1,000 to 1,600 circ.mil per ampere.

After the machine was put in operation, the no-load speed was found to be 1,040 r.p.m. and the speed when loaded was close to 950 r.p.m.

HENRY KAELIN.

Kaelin & Beer Electric Co.,
Los Angeles, Calif.

Tools for Armature Winder's Kit

THE tools mentioned in this list are considered necessary for the efficient repair of equipment handled by a large repair shop.

Number	Name of Tool	Use	Remarks
1	Steel stripping tool	For stripping armatures and open slots in a.c. stators and rotors.	Four thicknesses needed from ⅛ to ¾ in.
2	Coil lifting drift	For raising coils out of slots.	Make of fiber, steel or brass, ⅛ to ¾ in. thick.
3	Coil pullers	For pulling or sliding top side of coil into slot.	Two sizes needed.
4	Fiber winding drifts	For shaping ends of coils.	Sometimes called coil shapers. Various sizes are needed.
5	Fiber coil shaper	For shaping ends of coils.	Round nose type.
6	Coil lifters	For lifting tight coils out of slots.	Two sizes needed 11 in. and 14 in. long.
7	Wedge starter	For preparing entrance of slot.	The tapered nose is flared and rounded.
8	Fiber slot drifts	For driving coils into slots.	Six thicknesses needed varying from ⅛ to 1 in.
9	Lead drift	Feeding terminals in armature necks.	Six thicknesses needed varying from No. 8 to 16 gage.
10	Steel winding drift	.....	Sometimes called coil shaper.
11	Steel tapered drift	For wedging connectors.	Only very slight taper near point.
12	Lead lifters	For driving starter ends out of commutator when stripping armature.	Six thicknesses needed varying from No. 8 to 16 gage.
13	Steel slot drift	For semi-closed slots.	Size needed 1 ½, 6 and 18 in. long.
14	Wedge drivers	For driving wedges on top of semi-closed slots.	One for heavy and one for light duty.
15	Commutator pick	For picking out short circuits	No. 6 gage wire.
16	Taping needle	For hooking tape around coils	Use No. 14 gage wire.
17	Coil hook	For trimming commutator segments.	Ruggedly constructed.
18	Chamfering tool	For undercutting commutator mica	Can be made from hacksaw blade.
19	One-sided chisel	For chopping off leads.	Sometimes called coil shaper. One only needed.
20	Undercutting saw	For undercutting commutator.	Hack-saw blade holder secured in fiber handle.
21	Push cutter	For trimming slot insulation.	Two sizes, ¼ and ½-in. wide.
22	Lead scraper	For cleaning end of coil leads.	Made of ⅛-in. stock.
23	Banding clamp	For putting tension on banding wire.	For light work omit teeth.

Other Tools Needed

Wedges	Shoemaker's knife	Steel draft pin
Soldering irons	Machinist's hammers	Calipers
Tin snips	Tinsmith's hammer	Dividers
Scissors	Rawhide mallet	Micrometer gage
Diagonal pliers	Three-cornered file	Hack-saw holders
Round-nose pliers	Medium files	Screwdrivers
Parallel pliers	Knife-edge file	Wire gage
Side cutting pliers	Prick punch	Monkey wrenches

NEW EQUIPMENT

For Plant Operation and Maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Barrel Stand

THE Red Rocker barrel stand, illustrated, has been placed on the market by the Economy Engineering Company, 2643 West Van Buren St., Chicago, Ill. With this stand one man, it is said, can lift a 500-lb. barrel or drum of oil, paint or other liquid from a standing position on the floor and lay it horizontally on the stand, as shown, for draining. The stand is made of electrically welded angle irons and is said to be rigid and strong.

The operation of placing a barrel or drum on the Red Rocker is somewhat

Application of Red Rocker to Lifting and Draining Oil Drum

similar to loading a two-wheeled warehouse type truck. The tip of the Red Rocker is slipped under the edge of the drum, as shown. The man then tips the drum back against the barrel stand and then rocks it on over to a horizontal position for drainage.

This barrel stand is made in two sizes; the smaller unit, raises the faucet 18 in. from the floor and the larger unit, 24 in. The two stands weigh 33 and 42 lb. respectively.

Solenoids

A NEW line of solenoids, including both alternating- and direct-current types, has been placed on the market by the General Electric Company, Schenectady, N. Y.

These solenoids have been especially designed for uniformity and flexibility and are made for all frequencies and voltages up to and including 550 volts. The different types vary from each other in size only.

Each size of solenoid has four types made up with the same frame. An a.c. solenoid can, it is said, be adapted for d.c. operation by simply changing coils and adding a cutout switch for which all frames are drilled. A pulling solenoid may be changed to a pushing solenoid by adding two standard pusher bars. The pole face of the plunger is cylindrical and fits into a cylindrical seat on the frame to insure quiet operation in any position.

In the direct-current type, one section of the coil is a high-resistance section, which is short-circuited by the cutout switch until the stroke is nearly completed. The cutout switch then opens and inserts this winding, no external resistance being necessary.

Gas-Powered Tractor

DEVELOPMENT and distribution of the Mercury Type-R, gas-powered tractor has been announced by Mercury Manufacturing Company, 4118 South Halsted St., Chicago, Ill. Power is supplied from a four-cylinder ($3\frac{3}{8}$x$4\frac{1}{4}$ in.) Continental Red Seal gasoline engine with an S.A.E. rating of 18.2 hp. The cylinders are cast en-bloc with removable head. A high-tension magneto with automatic spark control, a centrifugal water pump and pressure oil pump are standard equipment. An automotive tubular-type radiator is used.

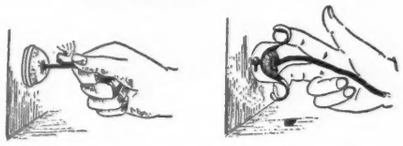
The multiple (seven-disk) dry-plate clutch and the selective type of transmission, with three speeds forward and one in reverse, are of Brown & Lipe manufacture. Control is of the standard automotive type. The major assemblies, such as: engine, clutch and transmission, chain sprockets and housing from transmission power take-off, propeller shaft, and rear axle are unit assemblies and each can be removed and replaced without interfering with the others. The main reduction (50 to 1 at low gear) is obtained through the Mercury patented, internal-gear drive in the rear axle. This drive applies the power to an internal gear on the inside of the rim of the rear driving wheels.

Mercury Type-R Gas-Powered Tractor

The separate emergency and service brakes each contracts a separate set of shoes on a 7-in. drum mounted on the propeller shaft. Exhaust gases are passed through 11 in. of condensing coil before entering a cast-iron baffle type muffler. It is stated that the gases are effectively cooled and condensed. For protection to the driver and the tractor a $\frac{5}{8}$-in. steel bumping plate is placed at front and rear. The tiller-bar type of steering and numerous other features are the same as are used on the line of Mercury electric storage battery tractors.

Puller for Plug Caps

CAPS on two-piece plugs should not be removed by pulling on the cord, but they are, and often the result is frayed wires or burned-out fuses. The Pull-A-Plug, which has been patented in the United States and Canada by the Ren Manufacturing Company, 550 Main St., Winchester, Mass., is an attachment to fasten onto standard plug caps and provide a grip for the fingers when pulling the plug cap.



Pull-A-Plug Made by Ren Manufacturing Company

This attachment is slipped over the plug cap and fastened by tightening a screw. The two curved arms form convenient grips for the fingers. The attachment, which is finished in black Japan to match the hard rubber or composition plug, also serves as shield and protects the plug cap from breakage.

Angle-Iron Shear

MARKETING of the No. 62 angle-iron shear has been announced by the Whitney Metal Tool Company, Rockford, Ill.

This angle-iron shear is very similar in appearance and has the same working principle as the No. 4 angle-iron shear manufactured by this company. The No. 62 unit is a heavier type, however, being capable of handling 3x3x$\frac{1}{4}$-in. angle iron.

This shear has an eccentric gear so that the leverage is equally distributed over the entire cutting blades, and there is also an adjusting screw provided so that all angles can be cut off squarely. A self-clamping pad is used in this machine for holding angles in position and a flat bar handle, milled to fit the socket, which prevents any loss of movement, is furnished with each shear. All wearing parts are hardened throughout. Inserted tool-steel blades are used.

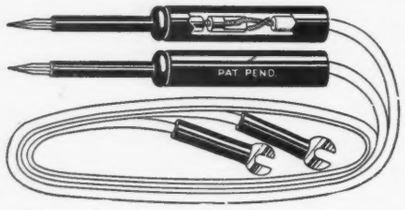
Voltage Relay Alarm

MARKETING of a voltage relay alarm which, it is stated, will ring a bell for 2 min. when power goes off and a buzzer for 15 sec. when the power returns is announced by the Iler Electric Service Company, Youngstown, Ohio.

This alarm is operated on 110-volt current but can be supplied for other voltages or designed for different time intervals of operation. The relay consumes 3 watts of power and is said to have no batteries or switches which must be operated.

Meco Test Handles

TWO new Meco handles for test prods, Nos. 115 and 117, have been placed on the market by the Metropolitan Manufacturing & Electric Company, 1163 Sedgwick St., Chicago, Ill., for use on its portable Trouble Shooter. These handles are used on battery, automotive, or other electric



Meco Handles for Test Prods on Trouble Shooter

test work and permit instant connection without tools, solder or tape.

The handles are slotted to facilitate changing leads. Any size of wire up to No. 8 B&S gage may be used. To change leads, it is only necessary to unscrew cap, pull out the leads and insert the new ones. The non-corrosive, rust-proof points are cadmium plated.

Electric Tachometer

THE addition of an electric tachometer to its line of Pyro instruments has been announced by The Pyrometer Instrument Company, 74 Reade St., New York, N. Y. The type A indicating unit is illustrated.

This Pyro electric tachometer will indicate speed up to 3,000 r.p.m. The generator is not a dynamo, according to the manufacturer, but operates on a novel application of the electric current generated by revolving its shaft in a magnetic field and rectifying the electric energy in such a manner as to enable it to operate a meter which shows the number of revolutions per minute. The meters are of either the plain indicating or the recording types and may be built into the tachometer or separately mounted.

The manufacturer also states that there are only two actuating parts in the

Type A Indicator for Pyro Electric Tachometer

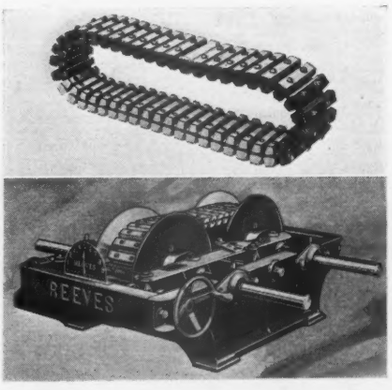
entire Pyro generator—the spindle or shaft and a small hardened pawl spring; therefore, the unit requires no care after installation, and no maintenance or replacements. This mechanism is compact and light in weight.

Variable Speed Transmission

SEVERAL improvements in the Reeves variable speed transmission have been announced by the manufacturer, Reeves Pulley Company, Columbus, Indiana. One of the most important features is the new double-block, center-pull construction of the V-belt which, it is stated, doubles the surface contact against the driving disks and also eliminates twisting action on the belt by making the driving center (or pitch line) at the center of the belt line. The double-blocks, one of which is on top and the other under the belt, are bolted on with a locknut instead of fastening by screws. The leather end-tips on the belt blocks are shaped to conform to the curved surface of the driving cones.

The new all-metal splice block is of the double-pin, interlocking type with cast-aluminum blocks and hardened alloy-steel pins. The splice is formed by bringing the ends of the belt together and inserting the two steel pins. Removing the pins, uncouples the belt. The splice-block is located at about the center of the upper loop of the belt in the accompanying illustration.

The frame of the new transmission



Double-Block V-Belt With All-Metal Interlocking Splice and New Reeves Variable Speed Transmission

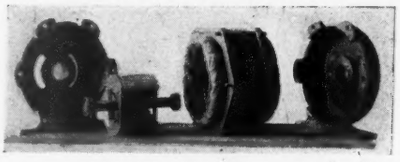
has been made more compact and stronger. Also, the bearing housings are turned inward and mounted in recesses in the frame instead of extending outward; this reduces the width of the unit. The feet on the frame are planed.

The bore of the disk hub is now grooved spirally, thus providing a more even distribution of the lubricant. The ball-thrust bearings have separate force feed fittings. A speed indicator is now standard equipment. A new shifting-screw lock prevents vibration from loosening the lock and shifting the speed setting.

Frequency Changer

SIMPLIFICATIONS have been made in the construction of its frequency changer which was announced on page 438 of the September, 1926, issue of INDUSTRIAL ENGINEERING by Forbes & Myers, 172 Union St., Worcester, Mass. The feature of that frequency changer was that it was built as a single unit without a driving motor.

This new development goes farther in



Disassembled View of Forbes & Myers Frequency Changer

simplifying the construction, but is suitable only for certain frequencies. The new unit, which this company is now placing on the market, is built in ratings from 1/10 to 3 kva., for changing two- or three-phase, 60-cycle power of any voltage to one-, two-, or three-phase, 180-cycle power. Other units are under development.

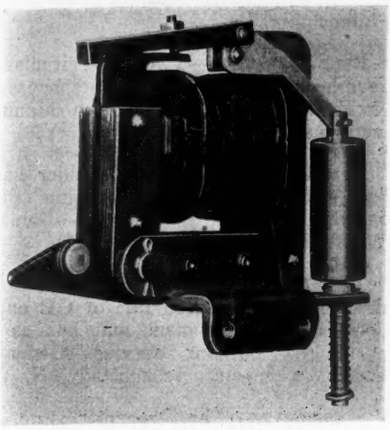
The construction of the frequency changer is similar to that of the ordinary induction motor. The stator has two windings—a two-pole winding, which is connected to 60-cycle power source, and a six-pole winding which delivers 180-cycle power. Both windings are placed in the same slots and are exactly like the windings of ordinary induction motors.

The rotor differs from that of the ordinary induction motor in that two opposite sections are cut away, which leaves only two-thirds of the usual rotor core. The rotor has bars and rings like induction motors. The frequency changer delivers three times the frequency of the power used. It is stated that the unit will go from no-load to full-load and even to short circuit without the slightest change in frequency.

The principal application is expected to be the operation of high-speed induction motors, such as are used for small grinding wheels or drills, portable tools, centrifugal separators, textile machinery and woodworking machines.

Time Delay Device

FOR those applications which are liable to voltage drops of short duration, the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has designed a time delay attachment for use on standard, low-voltage release equipment. This attachment is



Time-Delay, Low-Voltage Device for Westinghouse Auto-Starters

of particular advantage in paper mills and in other continuous processes where it would be a great inconvenience to have the plant shut down due to low voltage.

The new time delay device is provided with an adjustment which allows the low-voltage release to open from one-half to two and one-half seconds after the voltage drops below the minimum value. If the voltage remains low, longer than the time for which the time delay device is set, the motor circuit will be opened and the equipment protected from excessive currents. This device, it is claimed, will keep motors from shutting down due to short harmless surges caused by temporary short circuits and "bumps" due to switching. The usual method of stopping and starting with the auto-starter handle is not affected in any way by the addition of the time delay attachment.

The time delay attachment consists of a low-voltage magnet which has a dashpot for retarding its opening. After opening slowly a certain distance, a latch releases the magnet so that the starter opens quickly in the usual way. The time adjustment is obtained by varying the position of the fulcrum of the release latch. The dashpot is mounted with the open end down to prevent dirt entering.

Spray Painting Outfit

DISTRIBUTION of two sizes of Junior spray-painting outfits has been announced by Plummer-Huff Company, Napoleon, Ohio. The Junior Handigrip outfit with Cup Gun, assembly 1-B, consists of a motor-driven compressor, air tank, and Cup Gun, and has a rated coverage of about 8 sq.ft. per min. The larger 1-C Junior unit uses a Handigrip paint gun attached by hose to a 2-gal. paint tank and has a rated capacity of about 30 sq.ft. per min.

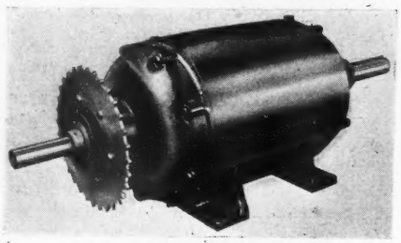
The Handigrip Cup Gun consists of a paint gun with a detachable paint cup clipped to the handle. To change colors it is only necessary to blow out the gun, it is stated, and put on another cup containing the new color. A paint hose can be attached in place of the cup. This Cup Gun is used for touch-up work and minor maintenance painting. The 1-C Junior outfit is intended for painting larger areas. Both units are portable and driven by a ½-hp. motor.

Some of the features of these guns, as stated by the manufacturer, are: balanced, drop-forged aluminum construction, two-finger trigger, spring valve control features, direct-in-line nozzle, operates on low pressure, ease in cleaning, and so on.

Speed Changer

A NEW speed changer, which may be directly connected to constant speed, high-speed motors, is being marketed by the Stephens-Adamson Manufacturing Company, Aurora, Ill.

This "JFS variable-speed transmission" is designed to provide variable speed over a wide range. The rate of rotation of the low-speed shaft, which may be direct connected to the driven machinery, may be changed without interruption while the machine is in motion, and the machine may be driven in either a clockwise or counter-clockwise direction.



Stephens-Adamson Speed Changer

The actual transmission of power is accomplished through the resulting action of roller bearings revolving in polished races, submerged in oil. The pressure between the rollers and races is sufficient to transmit the rated horsepower, it is claimed, at only a fraction of the allowable unit pressures common to the usual ball and roller bearing loadings. The hand or sprocket wheel is easily turned to adjust the rate of rotation of the low-speed shaft to any speed within the range.

The standard, variable-speed transmissions are made in sizes to transmit ½ to 15 hp. at the maximum reduction. There are two distinct series of these machines. The first series provides a reduction of approximately 8 to 1 for the lowest speed. The second series provides a reduction of approximately 40 to 1 for the lowest speed. Each of the series has a variable range of approximately 5 to 1.

Electric Fixture

A NEW Type Speederlight, No. 200, has been announced by the Multiple-Socket Fixture Company, 374 East 152nd St., Cleveland, Ohio.

This electric fixture can, it is said, be readily adjusted to any angle, forward or backward. If desired, a special Flexarm bracket can be furnished which will allow the fixture to be swung in an arc of 180 deg.

Rubber-Tired Steel Trailer

A STEEL trailer for general utility freighting, with rubber-tired wheels, complete ball and roller bearing equipment, and fitted with an automatic coupler to be known as the Clark Steel Trailer—Rubber Tired, has just been put in production by the Clark Tructractor Company, Battle Creek, Mich. This trailer, which is illustrated, is of the standard warehouse and shop size, with a 3x6-ft. diamond-plate steel platform 14 in. from the ground. The body is formed from a single sheet of ¼ in. diamond-plate steel. It is stated that the design provides a body and frame of exceptional strength and rigidity and that the diamond design prevents the load from slipping. Adjustable racks, which are interchangeable for use on ends or sides, are also provided.

Casters are of Clark design and swivel on eighteen 1-in. steel balls with a Timken bearing at the king-pin. Wheels are mounted on solid roller-type bearings of special design. Solid rubber tires are furnished on all four wheels. The rear tires are 12x4 in. and the caster tires, 10x3 in. The complete steel trailer weighs 550 lb. or 25 lb. more than the wooden trailer.

Claims made for this trailer are that it is noiseless, prevents wear and tear on expensive floors, pavements and platforms, reduces to a minimum breakage and claims due to injury of fragile loads, enables tractors to haul larger loads and longer trailer trains, trailer may be coupled and uncoupled by the driver without dismounting, and that the rubber tires also prevent sparks in paint and varnish shops which is a source of danger where metal trailer wheels are used on concrete floors.

Clark Steel Platform Trailer With Rubber Tires and Ball- and Roller-Bearing Casters

TRADE LITERATURE
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

MAGNETIC BRAKES—"When Industry Says Stop," is the interesting title of a new booklet on magnetic brakes which explains in detail the construction and operation of all types of C-H magnetic brakes for both alternating and direct current. Tables show the type and size of the brakes for use with various types of mill and crane motors.—The Cutler-Hammer Manufacturing Company, 150 Twelfth St., Milwaukee, Wis.

PROPELLER FANS—The line of Super Hi-Lo propeller fans is described and listed in a folder.—The Sinclair Equipment Corporation, 500 South Peoria St., Chicago, Ill.

ADJUSTABLE LAMPS — The Edon 100 Per Cent Adjustable Lamps for bench, table or machine mounting, are described and priced in a folder.—Edward Holt Company, 6911-23 South Chicago Ave., Chicago, Ill.

POWER DEMAND CONTROL — Bulletin 527 entitled, "How to Reduce Power Demand Charges," relates how the electrical engineer of an industrial plant reduced his power bill by $24,000 per year by studying the power demand with Esterline-Angus graphic instruments.—The Esterline-Angus Company, Indianapolis, Ind.

HOISTS—The Harrington line of electric hoists of from ½- to 1-ton ratings are described and illustrated in bulletin 40. Bulletin 44 covers hoist and trolley units.—The Harrington Company, Seventeenth and Callowhill Sts., Philadelphia, Pa.

HANDLING EQUIPMENT — An illustrated folder shows a wide variety of applications of Barrett material-handling equipment.—Barrett-Cravens Company, 1326 West Monroe St., Chicago, Ill.

BELT DRIVE — The first two of a series of articles by Roy C. Moore on leather belt drives, which have appeared in INDUSTRIAL ENGINEERING, have been reprinted for distribution.—Chas. A. Schieren Company, 31 Ferry St., New York, N. Y.

POWER TRANSMISSION MACHINERY—The complete line of Plamondon heavy gearing and friction clutches as well as other transmission machinery are covered in the new 190-page catalog 68.—A. Plamondon Division of Foote Bros. Gear & Machine Company, 236 North Curtis St., Chicago, Ill.

ALTERNATORS—Bulletin 151 gives, pictorially, information concerning the six types of alternators manufactured by this company. The flywheel requirements for engine-driven alternators are explained.—The Ideal Electric & Manufacturing Company, Mansfield, Ohio.

FURNACES—A series of bulletins describes the various types of Rockwell heat-treating furnaces using either electricity or fuel. One bulletin discusses the selection of fuel, on the basis of B.t.u. cost, for the heat treatment of metal.—W. F. Rockwell Company, 50 Church St., New York, N. Y.

WORM SPEED REDUCERS—The advantages of worm gearing and the details of design and construction are given in Catalog 35. The tabulation of horsepower capacities for both heavy-duty and medium-duty worm-gear speed reducers incorporates heat rating for continuous operation.—W. A. Jones Foundry & Machine Company, 4430 West Roosevelt Road, Chicago, Ill.

FLEXIBLE COUPLINGS — The three types of misalignment and how they may be taken care of by the Fast coupling is covered in a recent bulletin.—The Bartlett-Hayward Company, Scott and McHenry Sts., Baltimore, Md.

SYNCHRONOUS MOTORS — The application of direct-connected synchronous motors to refrigerant compressors is discussed in Bulletin 856. Numerous illustrations of applications are given.—Electric Machinery Manufacturing Company, Minneapolis, Minn.

UNIT HEATERS—A 32-page catalog illustrates and describes numerous installations of Skinner Bros. steam coil unit heaters.—Skinner Bros. Mfg. Company, Inc., 1400 S. Vandeventer Ave., St. Louis, Mo.

REFLECTORS—Catalog 179 contains descriptions of Abolite reflectors for every industrial need. It also contains full information on lighting requirements.—The Abolite Reflector Company, 2500 E. 75th St., Cleveland, Ohio.

METAL FURNITURE—Catalog No. 100 describes and illustrates the UHL line of steel equipment for office, factory and school.—The Toledo Metal Furniture Company, Toledo, Ohio.

CENTRIFUGAL BLOWERS—Centrifugal blowers and compressors as used in blast furnaces, steel plants and by-product coke oven plants are described, together with pumps, turbines and speed reducers, in Bulletin E1107.—De Laval Steam Turbine Company, Trenton, N. J.

HYDRAULIC MOTORS—Catalog C, recently issued, describes and illustrates Hele-Shaw hydraulic pumps and motors for high pressure hydraulic applications.—American Fluid Motors Company, Philadelphia, Pa.

BELT DRESSING—Two new circulars have been issued describing Stephenson bar belt dressing.—Stephenson Manufacturing Company, Albany, N. Y.

PORTABLE LAMP—A new folder has been issued recently describing the Protex safety portable lamp.—Daniel Woodhead Company, Chicago, Ill.

BUS SUPPORTS—Folder GEA 748A describes the standard line of GE outdoor station equipment and bus supports for outdoor service.—General Electric Company, Schenectady, N. Y.

EXPLOSIVES—The December issue of the Explosives Service Bulletin contains an interesting chart entitled "Brands of du Pont Explosives and uses to which they are adapted."—E. I. du Pont de Nemours & Co., Incorporated, Wilmington, Del.

SPRING WINDING TOOL—This tool has a changeable pitch adjustment and handles wire up to ¾ in.—Superior Spring Winding Tool Company, 774 Third St., Milwaukee, Wisc.

GROUND RESISTANCE TESTER—Megger instrument for testing all types of ground connections with one reading. Described in bulletin 1165.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

TRACTORS — "Snow Removal 1928 Edition," contains 66 pages showing the actual removal of snow in all sections of the country annually blanketed.—Caterpillar Tractor Co., San Leandro, Cal.

MOTORS—L. A. multi-speed squirrel cage a.c. motors are described in Bulletin 500.—The Louis Allis Company, Milwaukee, Wisc.

CENTRIFUGAL PUMPS—Bulletin 209—16 well illustrated pages devoted to a description of Pennsylvania double-section, single-stage centrifugal pumps.—Pennsylvania Pump & Compressor Company, Easton, Pa.

WIRE ROPE—An interesting booklet has recently been issued containing a brief historical sketch of the Hazard companies and their founders.—Hazard Manufacturing Company, Wilkes-Barre, Pa.

BLOWERS—Turbine blowers, for furnishing forced draft to both stokered and hand-fired boilers, are described and illustrated in bulletin No. 87.—L. J. Wing Co., 352 West 13th St., New York, N. Y.